Development and Spread of HIGH-YIELDING VARIETIES OF WHEAT AND RICE in the Less Developed Nations

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ABSTRACT

The use of high-yielding varieties (HYV's) of wheat and rice has expanded sharply in the less developed countries (LDC's) in recent years. This report reviews the development of these varieties and statistically documents their yearly spread. Major emphasis is placed on semi-dwarf varieties (1) developed at the International Maize and Wheat Improvement Center (CIMMYT) in Mexico and the International Rice Research Institute (IRRI) in the Philippines, and/or (2) offspring of these or similar varieties developed in national breeding programs.

Data cover the 12-year period from the 1965/66 crop year, when these varieties first came into use, through 1976/77. They are subject to a number of qualifications. As of 1976/77, the total HYV wheat and rice area in the non-Commuist LDC's totaled about 54.7 million hectares (135.1 million acres). Of this, about 29.4 million ha. (72.6 million acres) were wheat and 25.3 million ha. (62.5 million acres) were rice. HYV's represented about 34.5 percent of the total wheat and rice area; HYV wheat accounted for 44.3 percent of total wheat area and HYV rice accounted for 27.5 percent of total rice area. Additional areas of HYV's were planted in Israel, South Africa, and Taiwan, and in the Communist nations.

The largest proportion of the non-Communist LDC HYV wheat and rice area in 1976/77 was located in Asia, which represented 80 percent of the total. Asia was followed by Latin America with 11 percent, the Near East with 8 percent, and Africa with less than 1 percent. India had by far the largest HYV area, representing about 52 percent of the total. Over the 12-year period from 1965/66 to 1976/77, the HYV wheat and rice area in Asia rose steadily. The rate of increase is expected to slow in the future because of both supply and demand factors.

KEY WORDS: Wheat, rice, green revolution, high-yielding varieties, seed, agricultural research, agricultural development, developing countries.

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PREFACE

This is the sixth edition of this report. Previous editions were issued by the Economic Research Service (now a part of the Economics, Statistics, and Cooperative Service), U.S. Department of Agriculture, under the same title and FAER number in August 1976 and July 1974. Earlier editions, with a slightly different title and publication number (or no number), were issued in February 1972, January 1971, and November 1969. All are supplanted by this edition.

In this edition, the contents have been updated and several other changes have been made. The statistical portion of the report now covers the 12 crop years from 1965/66 to 1976/77, a period that represents the first dozen years of the "green revolution." Some fragmentary and preliminary area estimates are included for 1977/78. The data are, with a few exceptions, based on information in hand as of May 1978.

The more important modifications in this edition are:

- Chapter I. A brief discussion (and figure) on stages of varietal introduction has been added.
- Chapter II. A new review of sources of dwarfism has been added to both the wheat and rice sections.
- Chapters III and IV. Several new country entries, some of them formerly covered in footnotes, have been added in each chapter (this is particularly true of the wheat section for the Near East and the rice section for Africa). The introductions for several sections also have been enlarged and rewritten. Substantial new material on China has been included in both chapters.
- Chapter V. Reorganized and rewritten. Total estimates for all four LDC regions are included for the first time.
- Appendix. Two new appendices have been added (C, D).

While I would like to think that the overall report continues to be improved with each edition, this is not altogether the case for the statistical reporting in several regions. In the Near East, it has been possible to obtain estimates for two countries for which recent data were not previously available (Lebanon, Turkey), but recent estimates do not seem to be available for several other countries which were covered in earlier editions (Algeria, Iraq, Morocco). Some previously reported data are now considered inadequate and have been dropped (Iran, Morocco). In the Asia region, annual rice estimates are no longer available, at least to me, for two countries where there has been a change in government (Laos, South Vietnam). On the other hand, there have been some additions in coverage elsewhere. Still, the gains may not outweigh the losses.

As in the past, many individuals and organizations have cooperated generously in the preparation of the report. Most are cited in footnotes. Here, I would particularly like to acknowledge the many and continuing contributions of Dr. R. Glenn Anderson of the International Maize and Wheat Improvement Center (CIMMYT) and Dr. T. T. Chang of the International Rice Research Institute (IRRI). Drs. W. Ronnie Coffman and Thomas R. Hargrove of IRRI also provided much help with this edition. Collection of country data was largely

made possible through the assistance of agricultural attaché's of the U.S. Department of Agriculture (USDA) and food and agriculture officers of the U.S. Agency for International Development (AID). Assistance also was provided by staff members of the Ford Foundation, the Rockefeller Foundation, and the Food and Agriculture Organization of the United Nations (FAO). I, of course, owe a particular debt to a vast number of unknown individuals in developing nations who collect the country data summarized here.

FAO reported some rather scattered data it gathered several years ago on HYV wheat and rice in the *Monthly Bulletin of Agricultural Economics and Statistics*, December 1977, pp. 19-21. The FAO data cover area, yield, and production for the 3 years from 1972/73 to 1974/75. Barley and maize also are included. HYV's are not defined.

While an attempt has been made to make this report as accurate as possible, some errors—hopefully minor—may have gone undetected. These are most likely to be in the nature of imperfections in variety names and numbers.*

Funding for this project was, as in the past, provided through the Office of Agriculture, Development Support Bureau, AID. And as before, some work was done on this project while I was on part-time detail to the Bureau for Program and Policy Coordination, AID.

* One error of rather different nature is that the footnotes and most of the numbered tables appear in smaller type than intended. I apologize for any inconvenience this may cause.

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Abbreviations

AID, USAID—U.S. Agency for International Development
ARS—Agricultural Research Service (now Science and Education Administration-Federal Research), USDA
ERS—Economic Research Service (now a part of the Economics, Statistics, and Cooperatives Service), USDA
FAS—Foreign Agricultural Service, USDA
USDA—U.S. Department of Agriculture

CIAT—International Center for Tropical Agriculture (Colombia)
CIMMYT—International Maize and Wheat Improvement Center (Mexico)
ICARDA—International Center for Agricultural Research in the Dry Areas (Syria)
IITA—International Institute for Tropical Agriculture (Nigeria)
IRRI—International Rice Research Institute (Philippines)
WARDA—West African Rice Development Association (Liberia)

CY—Calendar year
FY—Fiscal year
HYV—High-yielding variety
LDC—Less developed country

Conversion Factors

1 hectare (ha.) = 2.471 acres
1 acre = 0.4047 hectare (ha.)
1 meter (m.) = 39.37 inches
1 centimeter (cm.) = 0.3937 inch
1 metric ton (M.T.) = 2,204.6 pounds
1 kilogram (kg.) = 2.2046 pounds

Table Key

NA = data not available
– = zero or virtually zero
negl. = negligible
prelim. = preliminary

SUMMARY

High-yielding varieties (HYV's) of wheat and rice have formed the core of what is popularly known as the "green revolution." This report summarizes historical information concerning their development and statistical data relating to their spread for the 12-year period from 1965/66 to 1976/77.

Emphasis is placed on semi-dwarf varieties (1) developed at what is now the International Maize and Wheat Improvement Center (CIMMYT) in Mexico and the International Rice Research Institute (IRRI) in the Philippines, and/or (2) offspring of these or similar varieties developed in national breeding programs. The relatively short, stiff stalk of the semi-dwarfs means that they repsond to improved cultural practices through increased yields rather than through increased plant growth which would also result in lodging (falling over of the plant).

The semi-dwarf HYV's in current use, while considered by some to be revolutionary in their impact, are the product of a long evolutionary and development process.

Semi-dwarf wheats were noticed in Japan in the 1800's. Early in the 20th century, several of these varieties found their way to Italy where they were used to breed improved varieties which later found wide use. Japanese breeders also crossed their varieties with several American types, ultimately resulting in the release of a Norin 10 variety in 1935. It was brought to the United States in 1946, again crossed with some American varieties, and taken to Mexico in the early 1950's. There the Norin-Brevor cross, in addition to some Italian varieties, was used by Dr. Norman Borlaug and his associates to develop the well-known Mexican varieties.

Early maturing rice varieties were known in China as early as 1000 A.D. Parents of the present IRRI varieties appear to have originated, at least in part, in China, Taiwan, and Indonesia. One common ancestor of the current IRRI varieties is Peta, which originated from a cross made in Indonesia in 1941. The semi-dwarf parent of the IRRI varieties, Dee-geo-woo-gen, is thought to have gone from China to Taiwan several hundred years ago. The first widely adapted IRRI variety, IR-8, was released in November 1966. Ten other varieties were subsequently released through July 1975. The newer varieties are being bred for improved resistance to insects and diseases as well as greater tolerance to climatic stresses.

The varietal process in most developing countries tends to go through three stages. The first is the use of traditional varieties. The second is the replacement of these varieties with improved varieties of conventional height. The third is the replacement of these varieties by short (generally semi-dwarf) high-yielding varieties. At first, some of the semi-dwarf varieties were the direct products of international centers, but increasingly the center germplasm has been used for breeding with local cultivars to develop varieties tailored to local conditions. The international centers no longer name and release wheat and rice varieties: this function has been taken up by the national programs.

While this process produces what might seem like a bewildering array of varietal names, virtually all of the semi-dwarfs used in the LDC's have one thing in common: their dwarfing gene. Essentially, the dwarfing genes of all the semi-dwarf wheats can be traced back to two Japanese varieties—principally through Norin 10. All the known semi-dwarf rice varieties are now thought to have the same dwarfing gene, first provided by Dee-geo-woo-gen. Other sources of dwarfism for wheat have been identified, and rice varieties of intermediate height have a more diverse genetic background. But the rather narrow genetic base of the dwarfing characteristic in rice may be a matter of some concern.

Although the dwarfing characteristic does facilitate classification, it does have some limitations. The dwarf habit alone does not guarantee high yields; many other factors are involved. Also, a variety does not always have to be short in height to be relatively high-yielding. And newer varieties developed for nonirrigated areas (and deep water conditions in the case of rice) probably will not be as short as their irrigated brethren. In any case, it is sometimes difficult to draw the precise line between semi-dwarf, intermediate, and tall varieties. And in some countries, no special distinction is made between the various categories of improved varieties; others do not have any area data on varieties.

These and other problems make it impossible to prepare a very precise compilation of the HYV areas of wheat and rice in all developing nations. But relatively good data exist for some countries, and it is possible to make approximations for others. Data have been compiled for individual developing nations, which have been grouped into four geographic regions. Information also has been gathered on Communist nations in Asia, as well as Taiwan, Israel, and the Republic of South Africa; these countries, however, are not included in the statistical summary.

The resulting data can be briefly summarized as follows for 1976/77:

Region	Wheat	Rice	Total
		Hectares	
Asia (South and East)	19,672,300	24,199,900	43,872,200
Near East (West Asia and North Africa)*	4,400,000	40,000	4,440,000
Africa (excl. N. Africa)*	225,000	115,000	340,000
Latin America	5,100,000*	920,000	6,020,000
Total	29,397,300	25,274,900	54,672,200
		Acres	
Asia (South and East)	48,610,300	59,798,000	108,408,300
Near East (West Asia and North Africa)*	10,872,400	98,800	10,971,200
Africa (excl. N. Africa)*	556,000	284,200	840,200
Latin America	12,602,100*	2,273,300	14,826,000
Total	72,640,800	62,454,300	135,095,100

* Particularly rough estimates of area.

The total HYV wheat area was somewhat larger than the total HYV rice area. In either case, the HYV area was largely concentrated in Asia. And within Asia, much of the area was in India; India, in fact, represented slightly over half of

the total HYV wheat and rice area in the non-Communist LDC's.

Comprehensive time series data are available only for Asia (4 countries for wheat and 11 countries for rice). Over the 12-year period 1965/66 to 1976/77, the total areas of wheat and rice each rose in about a straight-line trend. The rice area increased somewhat more steeply than the wheat. This increase continued unabated in 1975/76 and 1976/77. There were, however, some deviations from this trend in individual nations.

The HYV area data can be placed in sharper perspective by expressing them as a proportion of total area of wheat and rice. The approximate proportions for 1976/77 are as follows:

Region	Wheat	Rice	Total
		Percent	
Asia (South and East)	72.4	30.4	41.1
Near East (West Asia and North Africa)*	17.0	3.6	16.5
Africa (excl. N. Africa)*	22.5	2.7	6.5
Latin America	41.0*	13.0	30.8
Total	44.2	27.5	34.5

* Particularly rough estimate of area.

HYV wheats represent a somewhat larger proportion of total area than does HYV rice. The HYV wheat proportion is particularly high in Asia, and (if correct) higher than might be generally recognized in the other three regions. The HYV rice proportion also is highest in Asia (but less than half of the wheat proportion) and is coming up in Latin America, but is still quite low in the Near East and Africa. Within Asia, the HYV wheat populations are uniformly high in three of the four countries, while the HYV rice proportions are highest for the Philippines and Sri Lanka.

In the future, the rate of growth of initial HYV adoption may be expected to drop off because of a variety of supply and demand factors. On the other hand, newer varieties are continually being developed for a broader range of environmental conditions and consumer demands. Thus, the actual area covered by HYV's may continue to expand somewhat—even in countries with high rates of adoption. Other nations with a lower rate of adoption have substantial potential for expansion. In any case, the HYV's in use will continually be replaced by newer HYV's—a dynamic and never-ending process.

I. INTRODUCTION

The greatest service which can be rendered any country is to add an useful plant to its culture; especially, a bread grain . . .

—Thomas Jefferson, 1821[1]

The use of high-yielding varieties (HYV's) of wheat and rice has expanded sharply in the less developed countries (LDC's) in recent years. These varieties, along with critical inputs such as fertilizer and water control, have formed the basis for what is popularly known as the "green revolution." This report outlines the development of these varieties and documents the spread in their use.

BACKGROUND AND FOCUS OF THE REPORT

While the "green revolution" is a recent phenomenon in the LDC's, high-yielding varieties are not new. A vast number of wheat and rice varieties have probably, over time, been classified as high-yielding.

Improved yields can stem from any one of a number of biological characteristics or cultural practices. The distinguishing characteristic of the high-yielding wheat and rice varieties described in this report is their relatively short stem. They also are generally early maturing and have several other complementary plant features.[2]

Dwarf and semi-dwarf wheat and rice varieties have been known for more than a century. But they initially were more of curiosity interest than commercial value. The dwarfing characteristic, however, became of significant importance with the advent of chemical fertilizer.

The development of chemical fertilizer promised sharp boosts in yields for plants which could respond to its application and yet not lodge (fall over). This was particularly true in intensively farmed areas where the water supply was not a limiting factor. Hence, it is not surprising to find that the first efforts to develop such rice varieties probably occurred in Japan nearly a century ago.[3]

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[1] *The Jeffersonian Cyclopedia,* ed. by John P. Foley, Funk and Wagnalls Co., 1900, p. 697, item 6677.

[2] These include a higher tillering capacity, larger grain number per spikelet in the case of wheat, and the structure of the leaf canopy in the case of rice. For further details, see D. S. Athwal, "Semidwarf Rice and Wheat and Global Food Needs," *The Quarterly Review of Biology,* March 1971, pp. 24–26.

[3] In Japan, increasing application of commercial fertilizer (fishmeal, soybean cakes) in the late 1800's and chemical fertilizer in the early 1900's led to an early interest in the development of varieties with shorter stems. One of the first was selected in 1877 (Takane Matsuo, *Rice Culture in Japan,* Yokendo Ltd., Tokyo, 1955, p. 13). Semi-dwarf wheat varieties, as will be noted in Chapter II, already existed in Japan at this time.

The use of chemical fertilizer on domestic food crops in developing countries, however, is a more recent occurrence—beginning largely in the 1950's and 1960's.[4] The high-yielding wheat and rice varieties described in this report began to make their appearance in the LDC's in the 1960's, which, in turn, helped stimulate fertilizer use. The use of both HYV's and chemical fertilizer was stimulated by a food crisis in South Asia in the mid-1960's.

Thus, the HYV's, while having deep historical roots, are very much a product of their time. Some of the ancestry of most of the HYV's discussed in this paper can be traced to varieties developed in two international argicultural research programs—one with wheat in Mexico by Dr. Norman Borlaug and associates (subsequently grouped at the International Maize and Wheat Improvement Center—CIMMYT), and the other with rice in the Philippines at the International Rice Research Institute (IRRI). Other HYV's have been developed in national programs.

Basic information concerning the origin and interrelationships of the current HYV's is outlined in Chapter II. Chapters III, IV, and V provide estimates of the areas of HYV's planted or harvested in individual countries by crop years between 1965/66 and 1976/77, and some preliminary estimates for 1977/78 also are included. Scattered data on seed imports also are included where available. While the main focus is non-Communist nations, limited data on four Communist LDC's are included.

Clearly there is much other potentially useful statistical information and analysis about the HYV's which is not included in this report. No attempt is made to go beyond area data and to estimate increased yields and production.[5] Nor is any effort made to discuss the economic and social effects of the HYV's within the context of the "green revolution"—much literature is already available on this subject (a detailed list is provided in Appendix A of this bulletin). Rather, the purpose of this report is to provide a historical and statistical base for policy analysis and other research.

DEFINITIONS AND SOURCES OF DATA

Although the statistical data focus only on HYV area and seed imports, they are not without definitional complexities. The general characteristics, problems, and sources of data are outlined here; more specific details are in the footnotes in Chapters III and IV.

[4] Dana G. Dalrymple, *Evaluating Fertilizer Subsidies in Developing Countries*, U.S. Agency for International Development, Bureau for Program and Policy Coordination, Discussion Paper No. 30, July 1975, p. 3.

[5] Some of the major factors involved in this process, however, are outlined in a companion publication: Dana G. Dalrymple, *Measuring the Green Revolution: The Impact of Research on Wheat and Rice Production*, U.S. Department of Agriculture, Economic Research Service, FAER No. 106, July 1975, 40 pp. (An abridged and slightly revised version of this bulletin appears in *Resource Allocation and Productivity in National and International Agricultural Research*, ed. by T. M. Arndt, D. G. Dalrymple, and V. W. Ruttan, University of Minnesota Press, 1977, pp. 171–208.)

Varietal Definitions

The emphasis of this report is on (a) varieties of wheat and rice which were either developed by CIMMYT and IRRI, or (b) offspring of these or similar varieties developed in national research programs. Virtually all of these varieties are shorter than conventional or traditional varieties.[6] Most are semi-dwarf, but some might be considered intermediate in height (between semi-dwarf and tall).[7] These short varieties are potentially high-yielding. This yield capacity, however, is seldom fully realized on farms because of a host of physical, biological, and management factors which have been discussed elsewhere.[8] Thus, high-yielding refers to yield potential, and not necessarily to actual output.

This definition of HYV's does not, of course, include all improved wheat or rice varieties. Improved varieties of conventional height, produced as a result of scientific breeding or selection, have been under development in many LDC's for decades. (In India, for example, systematic research on wheat began in 1905 and on rice in 1911[9].) Improved varieties in turn may have significantly higher yields than traditional varieties—those which have evolved out of natural and human selection processes over centuries.[10] Many improved and traditional varieties are, of course, included in the ancestry of the current HYV's.

In most countries, a progression of varieties in three stages might be said to be involved: I, traditional varieties; II, improved varieties of normal height; and III, high-yielding varieties of shorter height, principally semi-dwarf and intermediate. While a few of the early varieties introduced or distributed by the international centers might have fallen in stage II, nearly all are now in stage III (with the reservations noted in fn. 6). Each stage may, in turn, be composed of successive waves of new varieties; few individual varieties have a very long life. Within Stage III, we would find a gradual replacement of imported CIMMYT and IRRI varieties with crosses of genetic materials from these centers with local varieties.

In most cases, the varietal sequence will follow the order indicated, but without one stage completely replacing the previous stage or stages. At a given point in time, all three stages can be expected to exist in most countries. In some instances, however, farmers may have skipped stage II and moved directly from stage I to stage III (particularly in the case of rice). And in some instances, bad experiences with newer varieties will lead farmers to temporarily move back

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[6] There are, however, significant exceptions in the case of both wheat and rice. The early wheat varieties released in the Mexican program were of normal height (see Chp. II). Several rice varieties of relatively tall stature are counted as HYV's. Some of the newer IRRI varieties under development for upland and deep-water conditions will not be as short as their predecessors (see fns. 32 and 33).

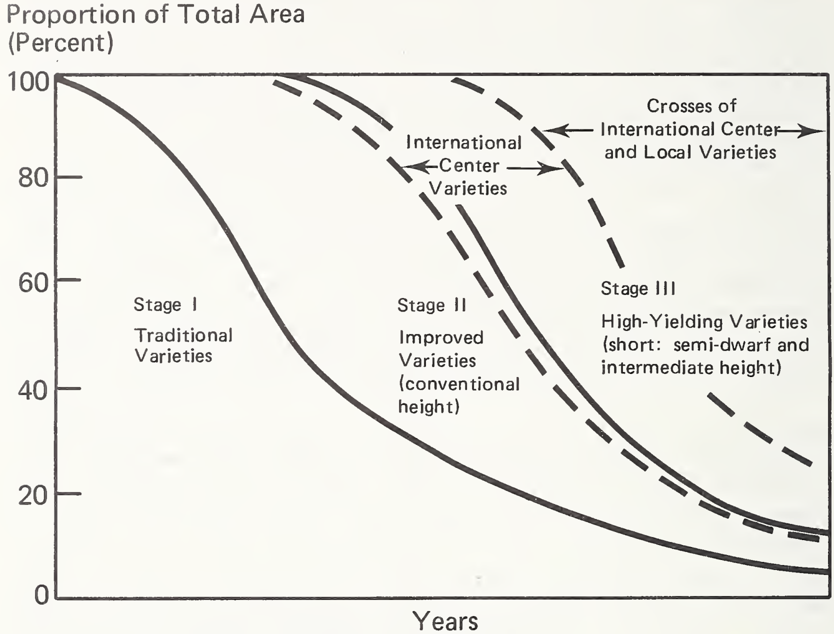
[7] For rice, rough height categories are: semi-dwarf, 80 to 120 cm.; intermediate, 120 to 140 cm.; and tall, over 140 cm. (A more precise classification might vary somewhat with location.) The intermediate classification has not been used as often with wheat. Dwarf varieties are seldom, if ever, grown commercially.

[8] These factors have been particularly well documented for rice in Asia. See: Randolph Barker and Theresa Anden, "Factors Influencing the Use of Modern Rice Technology in the Study Areas," in *Changes in Rice Farming in Selected Areas of Asia*, IRRI, 1975, pp. 17–40; Robert W. Herdt and Randolph Barker, *Multi-Site Tests, Environments, and Breeding Strategies for New Rice Technology*, IRRI, Research Paper Series No. 7, March 1977, 32 pp.; and *Constraints to High Yields on Asian Rice Farms: An Interim Report*, IRRI, October 1977, 235 pp. Brief accounts may be found in the annual *IRRI Research Highlights* reports.

[9] Albert Howard and G.L.C. Howard, *The Improvement of Indian Wheat*, Agricultural Research Institute, Pusa, Bulletin No. 171, 1927, pp. 1–16: M.S. Swaminathan, "Preface," in *India's Rice Revolution, A Beginning*, All-India Coordinated Rice Improvement Project, Hyderabad, 1974, p. i. See Appendix B for a review of the development of one of the better improved wheat varieties in the Near East.

[10] Some improved and traditional varieties may be as high-yielding as some semi-dwarfs under certain conditions. High yields are not an exclusive property of the semi-dwarfs.

Figure 1—Generalized Varietal Sequence for Wheat and Rice in Less Developed Nations



a stage or two. A generalized graphic presentation of these phases is provided in figure 1; the actual situation in an individual country may, of course, vary considerably.[11]

While an effort has been made to limit the data reported here to the semi-dwarf and intermediate HYV's of stage III (with exceptions noted in fn. 6), this has not always been possible. National data are not always broken down by specific variety. Thus, it is sometimes necessary to use whatever definition of HYV's was used by the national reporting system. This process has undoubtedly included some improved varieties. And the degree to which improved varieties are included may have changed over time.[12] Where the varietal composition is known, it is so reported.

A more subtle definitional problem arises from the time span covered in this report. Aside from the historical background in the next chapter, the report

[11] A particularly well-documented case is provided by Yoav Kislev and Michael Hoffman, "Research and Productivity in Wheat in Israel," *The Journal of Development Studies*, January 1978, p. 169.

[12] It has been reported, for example, that in India through 1968/69, improved local varieties were included in the HYV category. Thereafter, the definition was more strict. (V. S. Vyas, *India's High-Yielding Varieties Programme in Wheat, 1966–67 to 1971–72*, CIMMYT, 1975, pp. 5, 7.)

concentrates on the adoption of varieties that have been introduced by CIMMYT and IRRI since the mid-1960's. Semi-dwarf varieties introduced and widely adopted before that time are not specifically covered. Hence, the Ponlai rices which were developed in Taiwan in the early 1920's and widely planted thereafter are excluded. The same is true of the H series of rices in Sri Lanka. On the other hand, some of the offspring of these programs are included in national HYV figures; and one of the rice varieties developed earlier (Taichung Native 1) was distributed by IRRI.

While almost all of the HYV's reported here were developed by CIMMYT or IRRI, or are related in some way to such varieties, this is not always the case. The clearest example is some semi-dwarf varieties of wheat that were developed in Italy early this century and which are still planted in the Mediterranean region (this topic is discussed in greater detail in the next chapter). The same may be true of some Malaysian rice varieties, though by current standards some of them may not be semi-dwarfs or very productive.

The data cover only commercial plantings; no attempt has been made to summarize the area planted for research purposes. Therefore, many countries other than those listed may have HYV's under test, and may even have moved into limited commercial production.

Data Sources

Data on area and seed imports generally come from different sources. Most are unpublished. They apply, as far as possible, to July-to-June crop year.[13] In some cases, the sources do not indicate whether the data are for planted or harvested area; most, however, refer to planted area. For some nations (such as the Philippines) the data refer to harvested area; where there is a choice, harvested area has been used.

The area information is largely based on reports submitted by AID country missions or USDA agricultural attachés. These data, in turn, were usually obtained from official reports or estimates by the countries themselves. The national systems for collecting this information may not, in many cases, be very advanced. While the data have been checked as far as possible, there is really no good way of knowing how accurate they are. In some instances, the HYV area may be overestimated;[14] in others it may be understated;[15] and for others (such as Cambodia) it is simply not available. The area data, therefore, should be regarded as only approximate.

The seed figures are believed to be relatively accurate but quite incomplete except for unusually large shipments from Mexico, the Philippines, and India. Virtually all of the statistics on Philippine rice exports were provided by IRRI.

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[13] This process is not very precise and is subject to error, particularly where crop seasons, such as the aus (spring-summer) rice crop in Bangladesh, cut across the above time period. The assignment of some crops to specific crop years may, therefore, be open to question. The harvesting period follows the planting data by at least 3 months, creating further difficulties in making a consistent classification by crop years.

[14] There is evidence of substantial over-reporting of the HYV rice area in one district in India and in Bangladesh. Details are provided in Appendix C.

[15] In Turkey, for instance, the estimates cited in this report indicated an area of 623,000 to 650,000 ha. of Mexican varieties in 1971/72. Yet, a comprehensive independent survey during the same period suggests a total of about 1 million ha. (see table 20, fns. 3, 6). In some countries, such as Iran, the official data refer only to the area that could have been planted to HYV's from seed distributed under government programs; plantings from farmer sales of seeds are not included. The HYV wheat area in Bangladesh, in contrast to the HYV rice area, was found to be under-reported (Appendix C). The rice area in Indonesia in 1975/76 may have been under-reported (see table 24, fn. 10).

SOME BASIC BIOLOGICAL CHARACTERISTICS

While the basic biological characteristic of the high-yielding varieties discussed in this report is their semi-dwarf growth habit, some other biological features also are important. These features are in part related to their botanical classifications: there are several different major species and types of wheat and rice. Wheat and rice have somewhat different growing seasons, and their water needs also vary.

Classification of Wheat and Rice

In terms of botanical classification, wheat belong to the genus *Triticum* and rice to the genus *Oryza*. Wheat is composed of three species of commercial importance, while commercial rice is principally composed of one species.

Wheat.[16] The three major species of wheat are: common or bread wheat (*Triticum aestivum* L.); club wheats (*Triticum compactum* Host); and durum wheat (*Triticum durum* Desf.). Bread wheats were first extensively grown in northern Europe; club wheats in southern Europe; and the durum wheats in the Mediterranean countries, in southern and eastern Russia, and in Asia Minor. Each species has distinct characteristics which make it suitable for special uses: the common wheats are used for bread; the club wheats, which are soft, are used for pastry; and the durum wheats, which are hard, are used for products such as macaroni and spaghetti. Nearly all of the varieties reported in this publication are bread wheats. HYV durum varieties, however, are gaining in importance in the Mediterranean countries. Club wheats are presently of minor international importance.

Rice.[17] Asian or common rice (*Oryza sativa* L.) is the major species of cultivated rices. There are two major eco-geographic races within this species: indica and japonica. (Japonica is sometimes known as sinica or keng.)

Indica is the major group grown throughout South and Southeast Asia and in most areas of the People's Republic of China. The majority of indica varieties raised in the monsoon tropics have evolved from combined natural and human selection processes. They are well adapted to conditions of low soil fertility, uncertain weather, and poor water control. Most indicas have resistance to endemic diseases and insects and compete well with weeds. They also have the dry cooking characteristics preferred by consumers in tropical and subtropical areas. But the features that enable the tropical types of indicas to survive—tall and high-tillering plants, late maturity, long drooping leaves, etc.—also provide the basis for their weakness under modern agricultural practices. Improved fertilization, for instance, will lead mainly to vegetative growth and lodging rather than significantly increased yield.

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[16] Dr. L. W. Briggle of the Agricultural Research Service, U.S. Department of Agriculture, Beltsville, helped prepare this section.

[17] Dr. T. T. Chang of IRRI was a great help in preparing this section. For further details, see Takane Matsuo, *Rice and Rice Cultivation in Japan*, Institute of Asian Economic Affairs, Tokyo, 1961, pp. 9–25; T. T. Chang, "Rice," in *Evolution of Crop Plants* (N. W. Simmonds, ed.), Longman, London, 1976, pp. 98–104.

Japonica varieties are widely distributed in different areas of the temperate zone: lower Yangtze valley of China, Korea, Japan, Europe, parts of Australia, and California in the United States. The japonica varieties evolved in China more recently than the indicas and are the result of an intensive human selection process. In comparison with the indicas, they have darker and more upright leaves, a shorter and stiffer stalk, earlier maturity, and more thrifty vegetative growth. Japonicas respond well to improved cultural practices—especially fertilizer—and are more resistant to lodging. As a result, yields are considerably higher than for the indicas. Japonicas are not, however, well adapted to the traditional cultural practices in tropical Asia. Among other things, (1) the varieties require precise water, weed, and insect control; (2) most are susceptible to the virus diseases of the tropics; (3) some react to the high temperature during early growth stage by flowering too early; (4) they lack the grain dormancy needed in the monsoon season; and (5) the grains have a sticky cooking quality not desired by consumers.

Breeding efforts, outlined in the next chapter, have centered on improving each of these types as well as developing japonica and indica crosses.

Growing Seasons

Wheat is basically a temperate and semitropical crop, while various types of rices may be grown in regions ranging from the warmer temperature zones to the tropics. In each case, the normal range can be extended somewhat by breeding efforts and cultural practices.

Both the Mexican-type wheats and IRRI-type rices have some flexibility with respect to planting date in the developing nations. That is, they may be grown in the dry winter season and wet summer season. There are, however, some differences between the two crops.

Wheat. Wheat is of two types, winter and spring. Botanically, the Mexican varieties are spring wheats (i.e., planted in the spring and harvested in late summer). Where winters are mild, spring wheats may, like winter wheats, be planted in the fall and harvested in the spring. This practice is enhanced by the photoperiod-insensitive nature of the Mexican wheats. The winter culture of spring wheats is generally utilized in the less developed nations in warm regions.[18] In some regions where there is a heavy summer monsoon, culture of Mexican varieties may be largely limited to the winter season. Virtually all of the data reported here are for spring wheats, though some supplementary estimates for winter wheat are included for a few Near East countries.

Rice. The wet summer season is the traditional period for rice culture. Where irrigation or sufficient rainfall is available in tropical areas, rice may also be grown during the winter and spring months. In fact, in many areas, the IRRI-type rices are more responsive to nitrogen fertilizers and produce higher yields during the dry spring months when high solar radiation prevails.[19] Significant

[18] In Turkey, it is possible to plant Mexican varieties during the winter in the southern coastal areas, but it is necessary to use winter wheat varieties in the cold, dry Anatolian Plateau.

[19] T. T. Chang, "The Genetic Basis of Wide Adaptability and Yielding Ability of Rice Varieties in the Tropics," *International Rice Commission Newsletter*, 1967 (Vol. 16, No. 4), pp. 4–12. Most LDC's have low potential photosynthesis values in the wet summer months because of cloud cover; this is one reason why summer rice yields are relatively low in many LDC's (Jen-Ju Chang, "Potential Photosynthesis and Crop Productivity," *Annals of the Association of American Geographers*, 1970, p. 98).

quantities of the HYV's are planted during this period in some countries.[20] In addition, the photoperiod insensitivity of the HYV's usually shortens their growing period.[21] Photoperiod insensitivity and short growing seasons are not, however, desirable characteristics in every situation. Under certain environmental conditions, and during the wet season in low-lying areas of Asia, photoperiod sensitivity may be desirable. Development of HYV's for these conditions is only at an early stage.[22]

The shortened growing period of the HYV wheat and rice varieties facilitates multiple-cropping where weather and water supply permit. This characteristic is of major importance in some areas.[23]

Relation to Irrigation[24]

High-yielding types of both wheat and rice tend to be raised under irrigated conditions. Since the high-yield potential of the varieties is achieved by applying inputs such as fertilizer, an added cost is involved. When water control—both supply and drainage—is inadequate or unreliable, the added risk discourages the use of these and other inputs, and thus reduces or eliminates the advantage of the varieties.

Both the quality of irrigation systems and the need for irrigation vary widely in the developing nations. Irrigation systems range from virtually complete year-round supply to occasional supplementation of rainfall. Most commonly, the systems supplement rainfall during the wet season and service only a limited area during the dry season. High-yielding varieties do not require more water than local varieties in a physiological sense; in fact, because of higher yields and shorter growing periods, they may actually use less per unit of product. But, as noted above, the attainment of the full potential of the HYV's without undue risk requires an assured water supply. This increases the demand for water.[25]

Wheat and rice water requirements vary sharply. Rice, which is largely grown under flooded or paddy conditions, requires much more water per unit of land than wheat—over three times as much under some Indian conditions.[26]

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[20] During the 1976/77 season, the following proportions of HYV area were planted in the winter: Bangladesh, 39 percent; Indonesia, 42 percent; and Thailand, 83 percent (based on footnotes to country tables in Chapter IV).

[21] The extent to which this is true depends on the specific variety, location, and crop season. In the more heavily planted areas of Asia, the improved varieties mature in 105 to 135 days during the wet season, some 5 to 60 days sooner than traditional varieties (Palman 579 matures in 115 days in the Punjab State of India). There are a few exceptions associated with low temperatures and long days; during the aus (summer) season in Bangladesh, for example, some indigenous varieties may mature faster than IR-8 or IR-20. (Letter from T. T. Chang, IRRI, October 25, 1973; for details see Chang and B. S. Vergara, "Ecological and Genetic Aspects of Photoperiod-sensitivity and Thermo-sensitivity in Relation to the Regional Adaptability of Rice Varieties," *International Rice Commission Newsletter* June 1971. Also see B.S. Vergara and T.T. Chang, *The Flowering Response of the Rice Plant to Photoperiod; A Review of the Literature*, IRRI, Technical Bulletin 8, 1976 (third edition), 75 pp.).

[22] Photoperiod sensitive rice was the subject of an international seminar at the Bangladesh Rice Research Institute (held in cooperation with IRRI) in October 1977.

[23] For more information on multiple cropping, see: Dana G. Dalrymple, *Survey of Multiple Cropping in Less Developed Nations*, Economic Research Service, U.S. Department of Agriculture (in cooperation with AID), FAER No. 91, October 1971, 108 pp; R.I. Papendick, P.A. Sanchez, and G.B. Triplett (eds.), *Multiple Cropping*, American Society of Agronomy, Special Publication 27, 1977, 378 pp.; and Richard Harwood, "Multiple Cropping," International Agricultural Development Service, in press. Also see the IRRI annual reports.

[24] Drs. Randolph Barker and T. T. Chang of IRRI were of help in preparing this section.

[25] In economic parlance, the HYV's may raise the marginal value product (mvp) of water. This increase, however, may be of little practical value where added irrigation water is not available, as is often the case in canal irrigated regions. On the other hand, the higher mvp may stimulate tubewell installation or the purchase of tubewell water.

[26] Several references as summarized by Dalrymple, *op cit.*, October 1971, p. 31.

Thus, rice is most often raised in monsoon areas and wheat in the drier climates. Similarly, rice is more often grown during the wet season and wheat during the dry season. In some instances, where growing seasons permit, they are able to follow each other in multiple cropping rotations.[27] This is increasingly the case, for example, in Bangladesh.

Wheat. About two-thirds of the high-yielding wheat varieties are raised under irrigated conditions, principally in India and Pakistan.[28] Some important regions, however, such as north Africa and the barani (rainfed) area of Pakistan, receive little, if any, irrigation.[29] Even without irrigation, yields of the HYV's often are superior to local varieties. Consequently, increased attention is being given to developing drought-resistant wheat varieties.[30]

Rice. The high-yielding rice varieties are largely grown under irrigated lowland conditions and the remainder in the better rainfed areas. While precise figures are not available, the irrigated proportion is probably at least 75 percent for South and East Asia as a whole. The major exception is the Philippines where only 53 percent of the HYV's were grown on irrigated land in 1976/77 (table 29). As of the early 1970's, about 33 percent of the total rice area in South and East Asia fell into the irrigated category, 57 percent was rainfed (47 percent rainfed lowland and 10 percent rainfed upland), and 10 percent was deep water. Thus, the HYV's have largely been confined to a relatively small proportion of the rice area in Asia.[31] Research workers at IRRI and elsewhere are attempting to develop varieties which will better withstand the drought conditions associated with upland and rainfed lowland rice production,[32] or the deep water and poor drainage conditions in the low-lying areas of major river deltas.[33]

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[27] *Ibid.*, pp. 65, 71, 75, 78, 95; *CIMMYT Annual Report, 1972*, p. 46 (ref. to India).

[28] Letter from Don Winkelmann, CIMMYT economist (citing estimate by R. Glenn Anderson of CIMMYT), February 4, 1974; letter from Anderson, February 4, 1974.

[29] See, for example: Malcolm J. Purvis, "The New Varieties Under Dryland Conditions: Mexican Wheats in Tunisia," *American Journal of Agricultural Economics*, February 1973, pp. 54–57; R. I. Rochin, "A Micro-Economic Analysis of Smallholder Response to High-Yielding Varieties of Wheat in West Pakistan," Michigan State University, Dept. of Agricultural Economics, Ph.D. dissertation, 1971.

[30] One approach being used at CIMMYT is to cross spring wheat with winter wheat, which has greater drought tolerance (see *CIMMYT Review, 1977*, p. 69).

[31] Based on: a discussion with Randolph Barker, IRRI economist, February 4, 1976; R. Barker, H. E. Kauffman and R. W. Herdt, "Production Constraints and Priorities for Research," IRRI, Agr. Econ. Paper No. 75-8, April 1975, fig. 75-8. Also see Randolph Barker, "The Evolutionary Nature of New Rice Technology," *Food and Research Institute Studies*, Vol. X, No. 2, 1971, pp. 119, 121.

[32] For details, see *Major Research in Upland Rice*, IRRI, 1975, 255 pp.; "Drought Screening Quadrupled at IRRI," *The IRRI Reporter*, No. 4, 1977, pp. 1–3; and J. C. O'Toole and T. T. Chang, *Drought and Rice Improvement in Perspective*, IRRI, Research Paper Series No. 14, February 1978, 27 pp.

[33] For details, see: B.R. Jackson, *et al.*, "Breeding Rice for Deep-Water Areas," *Rice Breeding* 1972, IRRI, pp. 517–518; *Proceedings of the Workshop on Deep-Water Rice*, IRRI, 1977, 239 pp. Also see the IRRI annual reports.

II. ORIGIN AND DEVELOPMENT

The origin and development of the varieties reported in this bulletin are considerably more involved than their simple classification as semi-dwarf Mexican wheats and IRRI rice varieties might suggest.[1] Moreover, through history many varieties have emerged and been used which share at least some of their major characteristics.

HIGH-YIELDING WHEAT

The wheat varieties discussed here are descendents of Japanese, American, and Italian varieties and breeding efforts. These varieties first emerged, in recorded form, in the middle 1800's and the early 1900's.

They were not, however, the first to show some of the major characteristics of the present varieties. The earliest known example for wheat occurred on June 30, 1794, when the *American Mercury* of Hartford, Conn., published "An Account of a New Species of Wheat." The new variety was a hard winter wheat which, compared to the prevailing species, matured 15 to 20 days earlier, provided a heavier yield, and produced a third less straw on a short stem. It also was disease-resistant (particularly with respect to rust), and because of its earlier maturity escaped the worst damage of the Hessian fly. The variety was known as Forward Wheat and came from Caroline County, Va., where it had been selected 7 years earlier. Seed was offered for sale in Connecticut in September 1795. By 1798–1800, it was generally grown in eastern Virginia and Maryland, and was presumably adopted in the commercial wheat-growing areas of western New England.[2] Other such "modern" varieties may well have emerged unrecorded over time.

Japanese-American Roots

Japan has had a long history in the development of dwarf wheat. In 1873, Horace Capron, former U.S. Commissioner of Agriculture who headed an

[1] The reader desiring more technical detail than is provided in this chapter may wish to consult D. S. Athwal, "Semidwarf Rice and Wheat and Global Food Needs," *The Quarterly Review of Biology*, March 1971, pp. 1–34.; and Te-Tzu Chang, "Genetics and Evolution of the Green Revolution", IRRI, October 1977, mimeo, 43 pp. (Prepared for UNESCO Symposium of Genetics and Ethics, Madrid, October 1977.)

[2] Based on Chester M. Destler: " 'Forward Wheat' for New England: The Correspondence of John Taylor of Caroline with Jeremiah Wadsworth, in 1795," *Agricultural History*, July 1968, pp. 201–205; "The Gentleman Farmer and the New Agriculture: Jeremiah Wadsworth," *Agricultural History*, January 1972, pp. 145–147. Also noted in E. L. Jones, "Creative Disruptions in American Agriculture, 1620–1820," *Agricultural History*, October 1974, pp. 523–524.

agricultural advisory group to Japan, wrote that "the Japanese farmers have brought the art of dwarfing to perfection." He noted that "the wheat stalk seldom grows higher than 2 feet, and often not more than 20 inches." The head was short but heavy. The Japanese claimed that the straw had been so shortened" that no matter how much manure is used it will not grow longer, but rather the length of the wheat-head is increased." Capron noted that "on the richest soils and with the heaviest yields, the wheat stalks never fall down and lodge." [3]

Probably unknown to Capron, some Japanese wheat varieties had already been introduced in France. The first introduction occurred in mid-1867 when the "Société d'Acclimatation" of Paris received seed of a very productive early wheat ("blé précoce") listed as Haya Moughi, from a Dr. Mourier in Yokohama.[4] The seeds were planted by a member of the Society and a preliminary report was presented that fall. The stem or straw was short and the plant flowered early.[5] In the following years, other seeds were imported and numerous reports of trials of the "ble précoce" appeared in the *Bulletin* of the Society.[6] In 1880, it was listed in the well-known book, *Les Meilleurs Blés.* According to the description, the straw was very short, erect, and stiff; the plant was reported to flower 2 to 3 weeks ahead of all the other spring wheats. The entry, however, noted that the variety was more of curiosity interest than of true agricultural merit.[7] "Blé Précoce du Japon" was sold commercially from 1882 to 1904 as a spring wheat. It was used for experimental breeding work from 1930 to 1955, but does not appear to have been involved in the parentage of any significant commercial varieties.[8]

Two Japanese semi-dwarf varieties, however, did turn out to be of immense international consequence in subsequent breeding programs. They were Akakomugi and Daruma.

AKAKOMUGI [9].—Akakomugi means red wheat in Japanese. According to a book written in 1929, "Akakomugi was often used as a cross-parent because of dwarfness and early maturity." It was mainly raised in southern Japan but is no longer grown commercially. Akakomugi played an important role in the breeding of Italian semi-dwarf varieties early in the 20th century (discussed in a following section).

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[3] Horace Capron, "Agriculture in Japan," *Report of the Commissioner of Agriculture for the Year 1873*, Washington, 1874, p. 369.

[4] *Bulletin de la Société d'Acclimation*, Paris, 1867, pp. 453 ("Séance du 5 Julliet 1867"), p. 784. Subsequently, a Mr. Ramel claimed that he first drew attention to early Japanese wheat in 1862 and attempted to introduce it, but apparently was unable to obtain seed samples (*Ibid.*, 1869, p. 168).

[5] *Ibid.*, 1867, pp. 702–703.

[6] *Ibid:* 1868, pp. 514, 522–523, 665–666, 674; 1869, pp. 486–487; 1870, p. 229; 1871, p. 503; 1872, p. 788. Two entries suggested subsequent doubt that wheat was actually raised in Japan (1869, pp. 202, 703).

[7] [Henry Vilmorin] "Blé Précoce du Japon," *Les Meilleurs Blés*, Vilmorin-Andrieux & Co., Paris, 1880, pp. 120, 121. Vilmorin-Andrieux was one of the leading seed firms of France. The varieties also were noted in another Vilmorin-Andrieux publication: *Catalogue Méthodique et Synonymique des Froments*, 1889, pp. 18, 36, 39.

[8] Letters from: Kenneth E. Ogren, Agricultural Attaché, American Embassy, Paris, December 8, 1975; P. Martin, Union des Cooperatives Agricoles de Céréals (UCOPAC), Verneuil l'Etang, March 12, 1976. UCOPAC acquired the cereals branch of the Vilmorin-Andrieux firm; it still has a small stock of the seed. Martin notes that while the variety was short by the standards of the time, it would no longer be considered so. Martin kindly provided samples of the seed to USDA(ARS) in 1976 (PI-409010): it is being multiplied for future distribution and testing.

[9] This section is based on a letter from T. Gotoh, Wheat Breeder, Tohoku National Agricultural Experiment Station, Morioka, Japan, October 31, 1975. The book cited is Soshichiro Takeda, *Mugisaku Shinsetsu* (New Technique of Wheat Cultivation), 1929.

DARUMA[10].—Daruma became one of the recommended varieties in Tokyo and Kangawa prefectures around 1900.[11] In 1910, two strains of Daruma were recommended: Shiro(white)-daruma and Aka(red)-daruma. Daruma itself disappeared from the list of recommended varieties.[12] In 1917, Shiro-daruma (or perhaps Daruma) was crossed with Glassy Fultz at the Central Agricultural Experiment Station, Nishigahara, Tokyo, to produce Fultz-Daruma.[13] (Glassy Fultz was a selection of the American soft red winter variety Fultz.[14])

Fultz-Daruma in turn was crossed with the American hard red winter variety Turkey Red[15] at the Ehime Prefectural Agricultural Experiment Station in 1925[16] in an effort to produce rust-resistant, short-stemmed, early maturing varieties. The seeds of the first generation of the cross were transferred to the Konosu Experimental Farm of the National Agricultural Experiment Station and planted in 1926. Seed was subsequently sent to the Iwate Prefectural Agricultural Experiment Station in northeastern Japan.

A semi-dwarf selection developed from the seventh generation in 1932, Tohoku No. 34, was particularly promising. Following further testing, it was named *Norin 10* and registered and released in October 1935. The stem of Norin 10 was particularly short, having a length of 52 to 54 cm. Norin 10 was, in turn, used in breeding programs in Japan, the United States, and Mexico (the latter two cases are discussed in a following section). Shiro-daruma also was used at the Iwate Station to breed Norin 1 in 1929 and Norin 6 in 1932.

Italian Varieties[17]

In 1911, seed from some of the short-straw, early maturing Japanese wheat varieties was acquired by Dr. Ingegnoli, an Italian flower seed producer, during a trip to Japan. He provided the wheat seed to Nazareno Strampelli at the Royal

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[10] This section is largely based on letters from Gotoh, *op. cit.*, October 3, 1975, November 11, 1975, and February 9, 1978. Other references utilized were: Takeo Matsumoto, "Norin 10, A Dwarf Winter Wheat Variety," *Japan Agricultural Research Quarterly*, 1968, (Vol. 3, No. 4), pp. 22–26; Gonjiro Inazuka, "Norin 10, a Japanese Semi-Dwarf Wheat Variety," Wheat Information Service, Biological Laboratory, Kyoto University, No. 32, March 1971, pp. 25–30; L. P. Reitz and S. C. Salmon, "Origin, History, and Use of Norin 10 Wheat," *Crop Science*, November-December 1968, p. 686; letter from Hiroyuki Nishimura, Department of Agricultural Economics, Kyoto University, October 1, 1975; and letter from Noboru Yamada, Tropical Agricultural Research Center, Ministry of Agriculture and Forestry, Tokyo, October 31, 1975. (Gotoh provided a copy of the Inazuka article; Yamada a reprint of the Matsumoto paper.)

[11] The origin of Daruma is uncertain. It has been suggested that it was selected from a Korean land variety "Anznbaengi mill" (cripple wheat). (Letter from Chang Hwan Cho, Wheat Breeder, Wheat and Barley Research Institute, Suweon, Korea, March 15, 1978.) The matter needs further study.

[12] It is not certain whether the white and red (brown) strains existed before 1910 and were not distinguished in the terminology, or whether some sort of pure line selection was carried out. Systematic pure line selections of Shiro-daruma and Aka-daruma were made in the 1920's and the varieties were in use through the 1930's. (Gotoh, *op. cit.*, February 9, 1978.)

[13] The official records simply list Daruma; the use of Shiro-daruma is suggested by Inazuka, *op. cit.*, p. 25; Matsumoto, *op. cit.*, p. 23; and Yamada, *op. cit.*

[14] Fultz was first selected in Kansas in 1862. It was imported by the Japanese Government in 1887 (Gotoh, *op. cit.*, October 3, 1975). For details on Fultz, see J. A. Clark *et al.*, *Classification of American Wheat Varieties*. U.S. Department of Agriculture, Bulletin No. 1074, November 1922, pp. 83–85.

[15] Turkey Red, better known as Turkey, was introduced in Kansas in 1874 by a group of Russian Mennonites; it later became the leading U.S. variety. For details, see: Clark, *op. cit.*, pp. 144–147; and K. S. Quisenberry and L. P. Reitz, "Turkey Wheat: The Cornerstone of an Empire," *Agricultural History*, January 1974, pp. 98–114.

[16] The site of this original cross is incorrectly given in several accounts (Matsumoto places it at Konosu and Reitz and Salmon place it at Nishigahara). Attribution to Ehime is confirmed by: Inazuka, *op. cit.*, pp. 25–26; Gotoh, *op. cit.*, November 11, 1975; and Yamada, *op. cit.*

[17] This section developed out of brief mention of the Italian wheats in Reitz and Salmon, *op. cit.*, p. 688. Valuable assistance was provided by Dr. Reitz as well as by: A. Brandolini, FAO; and Alessandro Bozzini, Director, Laboratorio per le Applicazioni in Agricultura, Centro di Studi Nucleari della Casaccia, Rome.

Wheat Growing Experimental Station at Rieti. Strampelli started using the Japanese varieties in his breeding programs in 1912.[18]

Strampelli was interested in developing wheat plants which would be both early ripening and resistant to lodging. Early ripening was desired to increase resistance to blast or "stretta" (wilting under hot wind stress) and rusts, and to facilitate cropping. Resistance to lodging, obtained through shorter and thicker stems, was desired so fertilizer applications could be increased. These goals (aside from resistance to "stretta") were very similar to those of later breeding programs and seem to have been largely accomplished.[19]

Of the several Japanese varieties used by Strampelli, *Akakomugi* appeared to be the most important. In 1913, it was crossed with Wilhelmina Tarwe × Rieti (a cross involving Dutch and Italian varieties originally made in 1906), producing two lines: (1) *m.* 67, and (2) *21 ar.* The former produced Villa Glori (1918) among other well known varieties. The latter produced, among others, Ardito (1916) and Mentana (1918).[20]

Ardito was the first variety to attain wide use. It had short straw (70–80 cm.) and early maturing characteristics. By 1926, it accounted for nearly all of the 500,000 ha. (1,240,000 acres) planted to early maturing varieties in Italy.[21] Ardito also was grown in other areas of the world and became one of the progenitors of improved Argentine varieties and of the Russian winter variety Bezostaya.[22]

Mentana was the second major variety. It differed from Ardito in that it had earlier maturity and a longer stem (90–100 cm.). Mentana attained international popularity due to its resistance to yellow rusts. Its genetic traits were bred into Frontana (Brazil) and Kentana (Mexico).[23] Mentana also was one of three varieties which had a key role in the Mexican wheat breeding program in the 1940's.[24]

As a result of a wheat campaign in Italy, an estimated 1,261,000 ha. (3,116,000 acres) of early wheats were grown by 1932. This represented 25.4 percent of the total wheat area. The early wheats, mainly Mentana and Villa Glori, were particularly concentrated in the northern provinces.[25]

The typical varieties raised during the 1930's (such as Mentana) were taller than those used in the 1920's (such as Ardito). Subsequent breeding efforts placed increased emphasis on breeding a shorter stem, and the height of most varieties ranges from 65 to 85 cm.[26] Some varieties have a stalk length of less than 40 cm.[27]

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[18] Letters from Bozzini, *op. cit.*, December 5, 1973, February 5, 1974. In 1922, Strampelli moved to "The National Institute of Genetics as Related to the Cultivation of Cereals" in Rome. Biographical material on Strampelli is provided in *Nazareno Strampelli*, Societa Ploesana Produttori Sementi, Ramo Editoriale Degli Agricoltori, Rome, 1966, 44 pp.

[19] Nazareno Strampelli, *Early Ripening Wheats and the Advance of Italian Wheat Production*, Tipografia Failli, Rome, 1933, pp. 5–7.

[20] *Origini, Sviluppi, Lavori e Risultati*, Instituto Nazionale di Genetica per la Cerealicoltura in Roma, Rome, 1932, pp. 91, 92, 99–101, appendix. (Actual release dates for farm use were 4 or 5 years later than noted here.)

[21] Strampelli, *op cit.*, p. 11, maps and tables.

[22] Letters from: R. Glenn Anderson, International Maize and Wheat Improvement Center, October 19, 1973; Brandolini, *op. cit.*, March 8, 1974; Nicolae Saulescu and J. Vallega, in *Nazareno Strampelli, op. cit.*, pp. 30, 43. (The full pedigree of Bezostaya 1 is provided in *Cereal Improvement and Production*, Information Bulletin, Near East Project, FAO, 1971, No. 2–3.)

[23] Bozzini, *op. cit.*; Brandolini, *op. cit.*

[24] Norman E. Borlaug, "Wheat Breeding and Its Impact on World Food Supply," *Proceedings of the Third International Wheat Genetics Synposium*, Canberra, 1968, p. 5. The other two varieties were Florence Aurore (Marroqui)—see Appendix B—and Gabo.

[25] Strampelli, *op. cit.*

[26] Bozzini, *op cit.*

[27] Mario Bonvicini, "Indirizzi della Genetica Agraria per la Resistenza All'allettamento in Triticum Vulgare," *Caryologia* (Suppl. Atti del IX Congresso Internazional di Genetica), 1954, pp. 738–743.

Italian varieties are now being grown in several less developed countries in the Mediterranean region, particularly Morocco, Algeria, and Turkey. One of the better-known varieties is Strampelli; while it is susceptible to stem rust, it has good resistance to septoria.[28] Italian and Japanese varieties were used in early breeding work in Tunisia.[29] Italian varieties also are used widely in southeastern Europe.[30]

While the Italian varieties are generally early maturing and have relatively short straw, their stalk differs from the Mexican wheats. In some varieties, it is stiff and brittle with a completely upright head, in contrast to the more flexible Mexican-type straw.[31]

Italian varieties currently are being used in a number of nations, and appear to have been important in the development of other varieties, including some of the early Mexican varieties.

Mexican Varieties

In 1946, Dr. S. C. Salmon, a U.S. Department of Agriculture scientist acting as agricultural advisor to the occupation army in Japan, noticed Norin 10 growing at the Morioka Branch Research Station in northern Honshu. The stems were short, about 60 cm., but produced many full-sized heads. Dr. Salmon brought 16 varieties of this plant type to the United States. They were grown in a detention nursery for a year and then made available to breeders in seven locations.

Although Norin 10 was not satisfactory for direct use in the United States, it was useful for breeding.[32] Dr. Orville A. Vogel, a U.S. Department of Agriculture scientist stationed at Washington State University, was the first to recognize its worth and to use it in a breeding program in 1949. Crossing Norin 10 with U.S. varieties involved some problems, but a number of semi-dwarf lines eventually were developed. A Norin 10 × Brevor cross was to become particularly important.[33]

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[28] Anderson, *op. cit.*; letter from Willis McCuistion, Project Cereales—CIMMYT, Algiers, Algeria, December 11, 1973.

[29] F. Boeuf, "Le Blé en Tunisie," *Annales du Service Botanique et Agronomique*, Tunis, Tome VIII, 1932, pp. 96–110. In addition, several hybrids obtained from Emile Schribaux of Versailles early in the century reportedly had stiff stems and were early ripening (*Ibid.*, pp. 60, 61). The most important was Florence x Aurore (see Appendix B). Neither Florence Aurore or any of the other varieties appeared to be of Japanese or Italian origin (based on Appendix B and an examination of the names of the other varieties enlcosed with a cover letter from Schribeaux to Boeuf, December 2, 1922, a copy of which was kindly provided by P. Auriau, Station Genetique et d'Amelioration des Plantes, CNRA, Versailles, September 10, 1975).

[30] Letter from Bill C. Wright, Wheat Research and Training Center, Ankara, November 8, 1973. Wright specifically mentions Albania, Bulgaria, Hungary, and Yugoslavia. Also see Saulescu, *op. cit.*

[31] Anderson, *op. cit.*

[32] Norin 10, when grown in the United States and Mexico, proved to be daylight sensitive, very susceptible to rusts, and had shriveled or shrunken grain (letter from Charles F. Krull, Dekalb Italiana, Chiarno, Italy, January 29, 1976).

[33] Reitz and Salmon, *op. cit.*, pp. 686–687; L. P. Reitz, "Short Wheats Stand Tall," *1968 Yearbook of Agriculture*, U.S. Department of Agriculture, pp. 236–237; L. P. Reitz, "New Wheats and Social Progress," *Science*, September 4, 1970, pp. 952–955. Brevor was developed from a cross between Brevon (Turkey-Florence × Fortyfold-Federation) and an unnamed cross between Brevon's parents and Oro. It was developed cooperatively by the U.S. Department of Agriculture and the Washington Agricultural Experiment Station. The original cross was made in 1938, and the variety was released in the fall of 1949. (L. W. Briggle and L. P. Reitz, *Classification of Triticum Species and of Wheat Varieties Grown in the United States*, U.S. Department of Agriculture, Technical Bulletin No. 1278, May 1963, p. 64; discussion with Dr. Briggle, January 6, 1976.)

In the interim, word about the short-strawed germ plasm had reached Dr. Norman Borlaug in Mexico.[34] His breeding efforts had run to a yield plateau because of lodging under high levels of nitrogen fertilization. In his words:

> We had recognized the barriers in our search for a useable form of dwarfness to overcome this problem until the discovery of the so-called Norin dwarfs. In 1953 we received a few seeds of several F_2 selections from the cross Norin 10 × Brevor from Dr. Orville Vogel. Our first attempts to incorporate the Norin × Brevor dwarfness into Mexican wheats in 1954 were unsuccessful . . . A second attempt in 1955 was successful and immediately it became evident that a new type of wheat was forthcoming with higher yield potential.[35]

The introduction of the Norin 10 genes led to the development of a number of Mexican dwarf and semi-dwarf bread wheat varieties: Pitic 62, Penjamo 62, Sonora 63, Sonora 64, Mayo 64, Lerma Rojo 64, Inia 66, Tobari 66, Ciano 67, Norteno 67, and Siete Cerros. In addition, a semi-dwarf durum, Oviachic 65, was developed. (The number after each varietal name indicates the approximate year of introduction; Pitic 62 and Penjamo 62, for example, were first released to farmers in 1961.[36]) The genetic origins of these early hybrid varieties are depicted in figure 2.[37]

International diffusion of these varieties began very quickly at the experimental level. India and Pakistan were the first to be substantially involved.

The first Mexican wheats arrived in India in 1962 via the international rust nursery system. They caught the eye of Dr. M. S. Swaminathan of the Indian Agricultural Research Institute (IARI). In March and April of 1963, Borlaug, at the request of IARI, toured wheat areas in India. Upon his return to Mexico, he dispatched 100 kg. (220 pounds) of each of four varieties (Sonora 63, Sonora 64, Lerma Rojo, and Mayo), and small samples of 613 other selections. The material was grown and studied at seven locations during the 1963/64 season (as part of the All-India Coordinated Wheat Trials). In 1965, Lerma Rojo and Sonora 64 were released for general cultivation. Subsequently, 250 metric tons of Mexican

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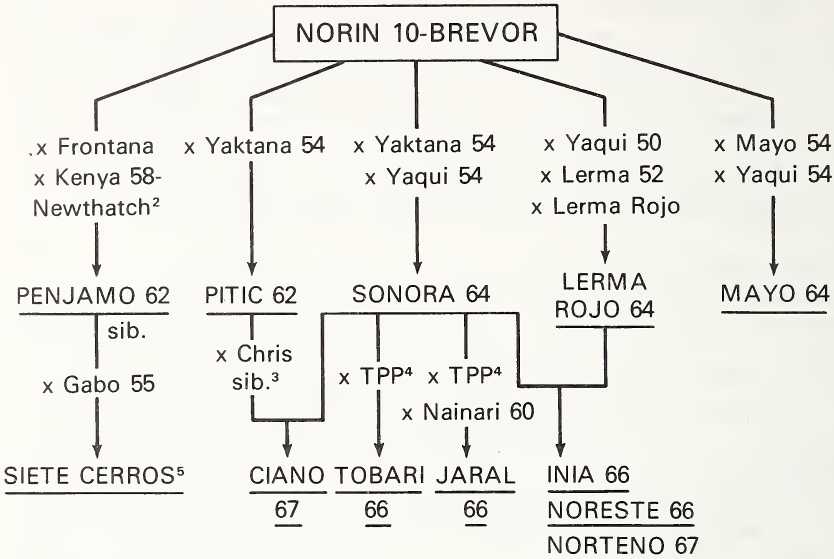
[34] The Rockefeller grain program in Mexico began in 1943. It was conducted in cooperation with the Office of Special Studies of the Ministry of Agriculture. In 1959, Borlaug became director of Rockefeller's International Wheat Improvement Project. The wheat program was merged with a comparable corn program in October 1963 to form the International Center for Corn and Wheat Improvement. Work sponsored by the Mexican Government was shifted from the Office of Special Studies to the National Institute of Agricultural Research in January 1961. (E. C. Stakman, R. Bradfield, and P. C. Mangelsdorf, *Campaigns Against Hunger*, Belknap/Harvard University Press, 1967, pp. 5, 12, 273.) For a more personal history of Borlaug's work, see Lennard Bickel, *Facing Starvation; Norman Borlaug and the Fight Against Hunger*, Readers Digest Press, 1974, 376 pp.

[35] Borlaug, *op. cit.*, p. 6. Although the Italian variety Mentana was, as noted in the previous section, used in early breeding efforts, it had a relatively long stem and was not in the semi-dwarf category; it did, however, introduce daylength insensitivity. For further discussion of the use of Mentana, see fn. 37 below and Stakman, *et al.*, *op. cit.*, pp. 84–88 (curiously, this book says very little about the Norin 10 types). For background on Borlaug's introduction to the Norin 10 × Brevor crosses, see Bickel *op. cit.*, pp. 198, 208, 209.

[36] Borlaug, *op. cit.*, pp. 6–7. Pitic was the first semi-dwarf variety to be released. Borlaug notes that these varieties did not have an effect on production until 1963.

[37] A more complete and more up-to-date graphic presentation is provided by Michael D. Gale and G.A. Marshall in "A Classification of Norin 10 and Tom Thumb Dwarfing Genes in Hexaploid Bread Wheat," *Proceedings of the Fifth International Wheat Genetics Symposium*, New Delhi, 1978, Figure 1 (in press). Mentana was one of the parents or grandparents of several of the varieties crossed with Norin 10-Brevor: Fontana (from Brazil), Lerma 52, Lerma Rojo[2], and Yaktana 54. It also was a parent of: Gabo 60; Kentana 48, 51, 52; Lerma 50, 51; and Nainari 60. Florence Aurore, under the name Marroqui, was one of the parents of Yaqui 50, as well as of Mayo 48 and Yaqui 48. (Letter from R. G. Anderson, CIMMYT, February 25, 1974; Brandolini, *op. cit.*; Stakman, *et al.*, *op. cit.*, p. 86, "Nombre, Genealogia y Abreviaturas de Trigos Mexicanos," Ministry of Agriculture and CIMMYT, September 1967, 4 pp.)

Figure 2—Genealogy of Early Semi-Dwarf CIMMYT Wheat Varieties[1]



[1]*The presentation of some of the more complex crosses is simplified for graphic purposes.*
[2]*Frontana x Kenya 58-Newthatch was bred in Minnesota.*
[3]*From Minnesota.*
[4]*Tezanos Pintos Precoz; from Argentina.*
[5]*Also known as cross 8156; see table 2.*

seed were purchased for planting during the 1965 season and 18,000 tons for the 1966/67 season.[38]

In the spring of 1962, Borlaug gave some of the improved seeds to two trainees from Pakistan. The seeds subsequently were planted at the Agricultural Research Institute near Lyallpur. Borlaug visited Lyallpur in the spring of 1963 on the way back from India, and upon his return to Mexico sent 450 pounds of experimental seed. Borlaug visited Pakistan in the spring of 1964 and soon secured governmental and foundation support for the varieties. Pakistan purchased 350 metric tons of Mexican seed for planting during the 1965/66 season and 42,000 tons for the 1967/68 season.[39]

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[38] Bickel, *op. cit.*, pp. 243–246, 255–256, 259, 274–279; M. S. Swaminathan, "Preface," in *Five Years of Research in Dwarf Wheats*, Indian Agricultural Research Institute, New Delhi, 1968, p. i., also pp. 3–5; Carroll P. Streeter, *A Partnership to Improve Food Production in India*, The Rockefeller Foundation, New York, 1970, p. 12. Also see V. S. Vyas, *India's High-Yielding Varieties Programme in Wheat, 1966–67 to 1971–72*, CIMMYT, 1975, pp. 1–9.

[39] Bickel, *op. cit.*, pp. 243–279. Further statistics on the seed purchases also are provided in Chapter III. Also see Jerry B. Eckert, "Farmer Response to High-Yielding Wheat in Pakistan's Punjab," in *Tradition and Dynamics in Small-Farm Agriculture* (ed. by Robert B. Stevens), Iowa State University Press, 1977, pp. 149–176.

The Mexican varieties proved remarkably adapted to India and Pakistan. The reasons for this are explained by Rao as follows:

- They had been bred in Mexico with alternate generations in different climatic and daylength regimes, primarily to get two generations a year. A valuable side effect of this system was to establish a good degree of insensitiveness to photoperiod.
- Selection for disease resistance also had been practiced, and the stocks introduced were found to show a remarkable level of resistance under Indian conditions.
- A further important feature of the original stocks was their diversity. They had not been bred to pure line standards, and there remained in them a reservoir of genetic potential that Indian wheat breeders were quick to exploit.[40]

The process of varietal change has gone through four stages in India. The first might be said to be the large imports of seed in the summers of 1965 and 1966. These were composed of Sonora 64 and Lerma Rojo, both with a red grain. The second stage ran through 1970 and consisted of selections made from these and some of the other varieties provided by Borlaug in 1963; the most prominent of the latter group was line 8156. Selection of amber-grained strains was emphasized. Leading varieties were: Sharbati Sonora, Safred Lerma, Kalyan Sona, Sonalika, and Chotti Lerma. The third stage consisted of the development of Indian varieties from materials imported from elsewhere and subsequently selected entirely under Indian conditions. Early varieties in this category were Lal Bahadur, U.P. 301, and Kiran. The fourth stage represented varieties that are being developed from crosses made in India, most frequently involving Indian and CIMMYT-Mexican parents.[41] India is still involved in the third and fourth stages, which include double and triple dwarfs.[42] Disease problems and other difficulties in recent years have led to a renewed emphasis on the development of new varieties.[43]

Details on varieties of Mexican origin or descent used in other developing countries as of 1974 are provided in table 1. Of the many Mexican lines and varieties, offspring of cross 8156 (fig. 2, fn. 5) have been most widely planted. Of the area planted to HYV wheat in India, Pakistan, Afghanistan, and Nepal in 1973, CIMMYT estimates that about 65 percent originated from cross 8156. The proportion in the Middle East and Africa may have reached 50 percent.[44] Local names which have been used for this cross are provided in table 2. In recent years, the area planted to the 8156 cross has declined as new races of rust have arisen and because of susceptibility to septoria.[45]

CIMMYT does not view the development of finished varieties as its main purpose; rather, it provides improved lines to national programs which, in turn,

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[40] M. V. Rao, "Wheat," in *Evolutionary Studies in World Crops; Diversity and Change in the Indian Subcontinent* (ed. by Sir Joseph Hutchinson), Cambridge University Press, 1974, p. 40.

[41] Developed from materials provided in: Streeter, *op. cit.*, pp. 12–17; letter from James H. Boulware, Agricultural Attaché, American Embassy, New Delhi, June 12, 1970; *Evaluation Study of High-Yielding Varieties Programme, Report for the Rabi 1968–69—Wheat, Paddy and Jowar*, Government of India, Planning Commission, Program Evaluation Organization, p. ii; *CIMMYT, 1969–70 Report*, pp. 85–96.

[42] See: Rao, *op. cit.*, pp. 42–43; A. B. Joshi, "Advances in the Development of Improved and High-Yielding Crop Varieties in India and Future Prospects," *Proceedings of the Fourth FAO/Rockefeller Foundation Wheat Seminar* (Tehran, May/June 1973), FAO, Rome, 1974, pp. 180–181.

[43] Richard Critchfield, "India: The Lost Years," *The New Republic*, June 15, 1974; D. V. Khosla, "India's Researchers Seek Higher Yielding Seeds," *Foreign Agriculture*, February 16, 1976, pp. 14, 15.

[44] "Worldwide Use of CIMMYT Bread Wheat Germ Plasm," *CIMMYT Review, 1975*, p. 99.

[45] *CIMMYT Review, 1977*, p. 53.

Table 1.—Mexican Bread Wheat Varieties Used in Developing Countries, Early 1970's

Variety	Mexican identification	Year released[1]
ASIA (South and East)		
BANGLADESH		
Norteño 67	Norteño 67	74 D
Mexipak 67	Siete Cerros	68 D
INDIA		
Kalyansona	Siete Cerros	67 R
P.V. 18	Super X	
Sonalika	(53–388–AN x Pi "S"-LR)(B4946–A4–18–2 x Y53) $Y50^3$	67 R
Chhoti Lerma	LR64 "S"-Hua. R.	67 R
Safed Lerma	Y^{50} E-L52/LR	67 R
UP 301	Inia 66 "S"	69 R
Sharbati Sonora	Sonora 64 "S"	67 M
Lerma Rojo 64A	Lerma Rojo 64A	65 D
Sonora 64	Sonora 64	65 D
Lal Bahadur	554723 x R 631–1	69 L
Hira	Pi "S"-Son 64	71 L
Moti	Pi "S" x NP 852	71 L
Janak	Pi "S" x HD 854	73 L
Malavika (durum)	(Pi "S" x TAC125)TA^4 x Z-B Wells x Lakota	73 R
UP 215	Tobari "S"	73 R
Shera	LR64A x Son 64	73 R
HD 2009(Arjun)	LR x Nai 60	74 R
HD 1981(Pratap)	Pi "S" x HD845	74 R
NEPAL		
Lerma Rojo 64	Lerma Rojo 64	67 D
Sonalika	Sonalika (India)	68 D
Kalyansona	Siete Cerros	67 D
Lerma 52	Lerma 52	53 D
PAKISTAN		
Mexipak 65	Siete Cerros	67 D
Mexipak 69	Siete Cerros	68 R
Indus 66	Super X	66 D
Penjamo 62	Penjamo 62	65 D
Khushal 69	Combinador x C271	69 L
Tarnab 69	2813 (Y62–63)-C271	69 L
Blue Silver	Sonalika (India)	69 D
Chenab 70	C271–Wt_E x Son 64	70 L
Barani 70	Pi "62"–Gb55 x C271	70 L
Green Valley	Chhoti Lerma (India)	70 D
Kalam 71	Combinador x C271	71 L
S.A. 42	$C271^2$ x LR-Son 64	72 R
NEAR EAST (West Asia, North Africa)		
AFGHANISTAN		
Mexipak	Siete Cerros	68 D
Lerma Rojo	Lerma Rojo	68 D
Bakhtar		72 R
Ephrat		73 D
ALGERIA		
Siete Cerros	Siete Cerros	72D
Inia	Inia 66	72D
Jori (durum)	Jori 69	72D
Tobari 66	Tobari 66	72D
Soltane	Soltane (Tunisia)	74D
EGYPT		
Super X	Super X	71D
Mexipak	Siete Cerros	72D
Chenab 70	Chenab 70 (Pakistan)	73D
S.A. 42	S.A. 42 (Pakistan)	73D

[1] D = Direct release, R = Reselection, L = Local breeding, M = Mutation

Variety	Mexican identification	Year released[1]
IRAN		
Inia	Inia 66	68D
Moghan	LR-NIOB x AN^3 E (Anza)	73R
Karaj 1	(200H-Vilufen) Roshan	73L
Arvani 1	Roshan/Mentana-Kenya x Mayo 48	73L
Khazar 1	P4160$_E$-Narino 59 x LR64A	73R
IRAQ		
Mexipak	Siete Cerros	67D
Inia 66	Inia 66	69D
Jori (durum)	Jori	72D
JORDAN		
Mexipak	Siete Cerros	69D
LEBANON		
Mexipak	Siete Cerros	67D
ARZ	My54$_E$ x LR/H490(LR64 x Tzpp-Y54)	73R
LIBYA		
Sidi Misri 1	Siete Cerros	72D
MOROCCO		
Siete Cerros	Siete Cerros	68D
Tobari	Tobari 66	68D
Penjamo	Penjamo 62	68D
Potam 70	Potam 70	72D
SAUDI ARABIA		
Mexipak	Siete Cerros	69D
Mexipak Red	Super X	69D
SYRIA		
Mexipak	Siete Cerros	71D
Pitic	Pitic 62	68D
Syrimex	Pi "S" x LR^3	69R
TUNISIA		
Inia	Inia 66	68D
Tobari	Tobari 66	68D
Soltane	Son-Kl. Rend.	74R
Vaga	Cajeme 71	74D
Amal (durum)	Brant "S"	74R
Maghrebi 72 (durum)	Gil "S" (Br180–LK)(GZ x 61–130)	74R
Carthage	Np-Tob "S" x 8156	74R
Dougga	Kl. Pet. Raf. x 8156	74R
TURKEY		
Mentana	Mentana	63D
Dicle 74 (durum)	Cocorit 71	74D
Cumhuriyet	(Son64^2 x Tzpp-Y54/An64A)Fr^2 .Y.Kt.(Cigueña)	74R
AFRICA (exclusing North Africa)		
ETHIOPIA		
Laketch	8156 white	70D
Kenya Kanga	Kenya Kanga (Kenya)	72D
Supremo-Kenya x Yq48		70D
KENYA		
Africa Mayo	Africa x Mayo 48	
Kenya Leopard	(Lageadinho x K. 354P^3) x (c. 1.12632 x K354P^3)	66L
Kenya Kanga	Mexicox [(Wis 245 x Sup. 51) x (Fr-Fn/Y^2).A]	71L
Trophy 68	T-K^2 x Y50	69R
Token	T-K^2 x Y50^2	69R
Kenya Kiboko	C18154–Fr^2 x (Gb54–36896)Gb54	73L
Kenya Nyati	Romany^2 x AfM	73L
RHODESIA		
Zambesi	8156 x Lee-ND74	66L
Tokwe	Mex [6 x Mezoe-ND74]	67L

[1] D = Direct release, R = Reselection, L = Local breeding, M = Mutation.

Variety	Mexican identification	Year released[1]
SUDAN		
Mexicani	LR-NIOB x $An^{3}{}_{E}$	71R
LATIN AMERICA		
ARGENTINA		
Precos Parana Inta	Son 64 x Knott 2	71R
Marco Juarez Inta	Son 64 x Kl. Rend	72R
Tala	(Son 64 x Kl. Rend) Mass. 5	73L
Lapacho/Urunday	Cno 67 "S" (sister of Bonanza)	73R
CHILE		
Toquifen	$C14^{4}$–P4160/Yt^{54}E	69L
Mexifen	Son 64 x Sk^{6} E-An^{3}E	71
Quilafen (durum)	$Ld357_{E}$-Tc^{2}	61D
COLOMBIA		
Bonza 63	Rio Negro x $Bonza^{2}$	63L
Tiba	Fr/Y48–My54 x Menkemen	63L
Zipa 68	F-Y 48 x Afm^{2}	68R
GUATEMALA		
Nariño 59	Nariño 59	60D
Pato	Tzpp-Son 64 x Nar 59	71D
Maya 74	Cno-Gallo	74R
MEXICO		
Lerma Rojo 64	Y50–N10B x $L52/LR^{2}$	64D
Siete Cerros 66	Pj 62"S"-Gb55	66D
Yecoro 70	Cno"S" x Son-Kl.Rend/8156	70D
Cajeme 71	Cno"S" x Son-Kl.Rend/8156	71D
Tanori 71	Son 64–Cno"S" x Inia	71D
Jori 69 (durum)		69D
Cocorit 71 (durum)		71D
Jupateco 73	II–12300 x LR64–8156/Nor 67	73D
Torim 73	Bb-Inia	73D
Cocoraque 75	Jupateco "S"	75D
Salamanca 75	Chonate #2	75D
Zaragoza 75	Meng.-8156	75D
Nacozari 76	Tzpp-A x Siete Cerros	76D
Pavon 76	Vem-Cno x Siete Cerros/Kal-Bb	76D
Tesopaco 76	Inia-Soty x Carazinho	76D

[1] D = Direct release, R = Reselection, L = Local breeding, M = Mutation

Source: "Worldwide Use of CIMMYT Bread Wheat Germ Plasm," *CIMMYT Review, 1975,* pp. 94–97 (also provides similar data for developing countries). Further information for Mexico was obtained from: *CIMMYT Review, 1977,* p. 51; and B. Skovmand and S. Rajaram, *Semidwarf Bread Wheats: Names, Parentage, Pedigrees, Origin,* CIMMYT, Information Bulletin No. 34, 1978, pp. 2–11.

Note: CIMMYT kindly provided an updated and considerably expanded list of varieties in use in developing nations (and others), but it arrived too late for incorporation into this table. Only some Mexican information has been utilized, and some corrections made. (The CIMMYT listing was in handwritten form and did not indicate year of release and the form of release; some of this information, however, is given by Skovmand and Rajaram, noted above.)

Table 2—Names Used for Cross 8156 in Various Countries

Red-seeded selection		White-seeded selection	
Name	Country	Name	Country
Super X	Mexico	8156 Blanco	Mexico
Siete Cerros Rojo	Mexico	Siete Cerros 66	Mexico
PV–18	India, Pakistan	Siete Cerros	Mexico
PV–18A	India	7 Cerros 66	Mexico
V–18	India	V–17	India
Indus 66	Pakistan	S–227	India
Mexipak Red	Saudi Arabia, Lebanon	Sona 227	India
MR 548	India	HD 1593	India
NP 323	India	HD 1592	India
CB 90	India	Kalyansona	India
PM 17	India	Kalyansona 227	India
		Kalyan 227	India
		Mexipak = Mxp.	Pakistan, Iraq, Syria
		Mexipak White	Lebanon
		Mexipak–65	Egypt, Lebanon, Pakistan
		Mexipak–69	Pakistan
		Mexi-Pack	Iraq
		Sidi Misri 1	Lybia
		Laketch	Ethiopia
		Mivhor 1177	Israel
		Hazera 1177	Israel
		Bakhtar	Afghanistan

Source: "Worldwide Use of CIMMYT Bread Wheat Germ Plasm," *CIMMYT Review, 1975,* p. 98. For similar, though less extensive, information on other crosses, see B. Skovmand and S. Rajaram, *Semidwarf Bread Wheats: Names, Parentage, Pedigrees, Origin,* CIMMYT, Information Bulletin No. 34, 1978, p. 12.

tailor them to local conditions. The Mexican Government has released a number of varieties and exported substantial quantities of seed.

As noted in Chapter I, most of the HYV wheats discussed in this report are bread wheats. However, considerable research has been carried out by CIMMYT and cooperating agencies to incorporate the Norin 10 dwarfing characteristic (as well as other features) into improved durum varieties. The work was begun in Mexico in the 1950's and, in 1965, the first semi-dwarf durum, Oviachic, was released. The two most widely used varieties as of 1975 were Jori and Cocorit; Jori was named and released by the Mexican Government in 1969 and Cocorit in 1971. In 1975, Mexico released Mexicali. Other varieties are undergoing development in Mexico and in the Middle East. While the Mexican bread wheat initially substituted for durum wheats in some regions in the Near East, this situation may be reversed with the introduction of improved durum varieties. The potential for further yield improvement in durums is considered great.[46]

[46] This section is based on Steven A. Breth, "Durum Wheat: New Age for an Old Crop," *CIMMYT Today*, No. 2, 1975, 16 pp.

Sources of Dwarfism[47]

Virtually all of the semi-dwarf varieties grown in the less developed countries utilize the dwarfing genes (Rht 1 and Rht 2) contained in two Japanese varieties noted earlier. *Daruma* is by far the most important source, principally through the use of its best-known offspring, Norin 10. Daruma is an ancestor of two well-known Korean semi-dwarf varieties, Suwon 92 and Seu Suen 27.[48] *Akakomugi*, as noted earlier, provided the dwarfing characteristic for a number of Italian varieties (and offspring such as Mara). The Daruma and Akakomugi dwarfing genes are thought to be different, but this is not certain.[49]

There are a number of well-known problems and perils in drawing on too narrow a genetic base for the dwarfing characteristic.[50] And there are some particular breeding problems with the above varieties, including the fact that the commonly used dwarfing genes are recessive. Accordingly, a number of alternative dwarfing sources have been studied over the years. The main sources have been the varieties Tom Thumb and Olesen's Dwarf. *Tom Thumb* is of uncertain origin.[51] It is a winter wheat variety which carries a different dwarfing

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[47] This is a complex subject which is not yet fully developed or resolved. The discussion presented here should be considered only preliminary. This section has benefited greatly from extensive correspondence with C.F. Konzak, Department of Agronomy and Soils, Washington State University and M.D. Gale, Plant Breeding Institute, Cambridge, England. Technical aspects are discussed in a number of recent papers. The following may be of special interest: G.N. Fick and C.O. Qualset, "Genes for Dwarfness in Wheat, Triticum Aestivum L.," *Genetics*, November 1973 (Vol. 75), pp. 531–539; C.F. Konzak, "A Review of Semidwarfing Gene Sources and a Description of Some New Mutants Useful for Breeding Short-Stature Wheats," in *Induced Mutuations in Cross Breeding*, International Atomic Energy Agency, Vienna, 1976, pp. 79–93; Michael D. Gale and C.N. Law, "The Identification and Exploitation of Norin 10 Semi-Dwarfing Genes," *Plant Breeding Institute Annual Report* (Cambridge, England), 1976, pp. 21–35. Gale and G.A. Marshall also have authored a recent paper on "A Classification of Norin 10 and Tom Thumb Dwarfing Genes in Hexaploid Wheat," to be published in the *Proceedings of the Fifth International Wheat Genetics Symposium*, New Delhi, 1978 (in press).

[48] Suweon 92 is an offspring of a cross between Suweon 13 and Suweon 85; Suweon 85 was derived from a Daruma x Fultz/Kanred cross originally made in Japan. Seu Seun 27 was derived from a cross of Suweon 90 (from the same cross as Suweon 92) and Shiroboro (from Japan). (Letter from Chang Hwan Cho, Chief, Wheat Breeding Division, Wheat and Barley Research Institute, Office of Rural Development, Suweon, January 16, 1978.). The ancestry of Suweon 85 is basically the same as Norin 10; Kanred was a selection from Crimean, which was one of several synonyms for Turkey Red. The original cross was made at the Rikuu Branch Experiment Station (Omagari, Akita Prefecture) and the F_3 seeds were sent to Suweon, where Suweon 85 was developed and registered as a new cultivar and released to farmers in 1933 (letter from T. Gotoh, Wheat Breeder, Tohoku National Agricultural Experiment Station, Morioka, February 9, 1978).

[49] Konzak, *op. cit.*, p. 80; Reitz and Salmon, *op. cit.*, p. 688; letters from Konzad, *op. cit.*, December 15, 1977, April 12, 1976. (Konzak is studying this matter further.)

[50] Background information on genetic vulnerability is provided in Peter R. Day (ed.), *The Genetic Basis of Epidemics in Agriculture*, New York Academy of Sciences, Annals, Vol. 287, February 1977, 400 pp.; and *Genetic Vulnerability of Major Crops*, National Academy of Sciences, Washington, D.C., 1972, 307 pp.

[51] The Tom Thumb variety carried in CIMMYT's collection reportedly was collected in Tibet in the 1930's as a curiosity. The wheat collection at the Plant Breeding Institute at Cambridge, England, however, contained a Tom Thumb variety as early as 1921; its origin is unknown. Moreover, a recent report by Zeven lists a Tom Pouce Blanc (TPB) and a Tom Pouce Barbu Rouge (TPBR). Earlier, Zeven cited Dr. P. Martin of Vilmorin-Andrieux, who provided some of the seed in 1960, as stating that "TPB was found in the old English variety Hybrid Carter G; TPBR probably originated from outcrossing in TPB." Both were quite short, 35 to 41 cm. The origin of Hybrid Carter G is not known, and it has not been possible to find any further reference to it. Zeven also indicates that the Tom Thumb of Tibet origin "resembles Tom Pouce closely," (Pouce is the French word for thumb.) Gale reports that TT, TPB, and TPBR all carry the Rht 3 gene. (Letters from Gale, *op. cit.*, March 8, 22, 1978; Gale and Marshall, *op. cit.*; A.C. Zevin, *Geneologies of 14,000 Wheat Varieties*, CIMMYT, 1976, p. 107; A.C.Zeven, "Tom Pouce Blanc and Tom Pouce Barbu Rouge, Two *Triticum Aestivum* Sources of Very Short Straw," Wheat Information Service, Tokyo, 1969, Vol. 29, pp. 8–9; letters from Konzak, *op. cit.*, March 23, 31, 1978).

The Tom Thumb variety in the USDA collection (CI-13563) has been traced back to the Plant Breeding Institute at Cambridge. The route was as follows: (1) the Scottish Society for Research in Plant Breeding obtained samples from the Institute in 1935; (2) the society sent samples to C.H. Goulden at the Central Experimental Farm of the Canada Department of Agriculture in November 1948 (in requesting the seed Goulden identified it as being from Gartons, a British seed firm); (3) Goulden gave samples to B. Charles Jenkins, who was in charge of winter wheat breeding at Lethbridge, Alberta; and (4) Dr. R.E. Allen, a USDA scientist stationed at Pullman, Wash., obtained samples from Jenkins after the 1st Wheat Genetics Symposium in Winnipeg. (Letters from: R.C.F. Mercer, Scottish Plant Breeding Station, Midlothian, May 16, 1978; D.R. Sampson, Cereal Section, Ottawa Research Station, Agriculture Canada, Ottawa, April 19, 1978; B. Charles Jenkins, Jenkins Foundation for Research, Salinas, Calif., March 27, 1977; Konzak, March 23, 1978.)

gene (Rht 3) than those carried by Norin 10 (Rht 1 and Rht 2). *Olesen's Dwarf* was developed by Dr. O.J. Olesen of the Ministry of Agriculture of Southern Rhodesia.[52] It carries the Rht 1 and Rht 2 genes plus a third gene of uncertain origin.[53] CIMMYT received the Olesen's Dwarf seed in about 1964 and used it, along with Tom Thumb, in a now discontinued program to develop hybrid wheat.[54] In the early 1970's, CIMMYT started using another Rhodesian variety, *S948–A1* (Pitic sib x Mazoe); it is of spring habit and is similar to Olesen's Dwarf.[55] Like Norin 10, these varieties are not of direct commercial use, but may be of value in breeding programs.

CIMMYT resumed use of these varieties in its bread wheat breeding program in 1974. They were utilized to shorten some of the older Mexican tall varieties (such as INIA, CIANO, and Bonza) and to further increase yields. Yield trials in 1975 and 1976 indicated that the backcross lines out-yielded the tall parents. These lines are being incorporated in the bread wheat breeding program. Other newer semi-dwarf varieties (such as Pitic, Penjamo, Lerma Rojo, Japateco, Cocorit, and Mexicali) are now being crossed with S948–A1 to further reduce their height.[56]

CIMMYT also has identified two other possible sources of dwarfing. One is a dwarf winter wheat known as *Hisumi*, which was used for the first time in 1976.[57] The other is *Hweihisien Red*, which was obtained by a CIMMYT team visiting the People's Republic of China in 1977. Hweihisien is a historic Chinese winter wheat. It was crossed with a well-known Italian wheat named Abbondanza[58] to produce a variety known as T'aishan 4, which is grown on 700,000 hectares in three Chinese provinces.[59] It is unclear at this point whether these varieties have different dwarfing genes.

Some other Chinese varieties with dwarfing genes also are under study by Dr. C.F. Konzak at Washington State University. They were obtained largely by Dr. H.H. Love of Cornell University in the late 1920's. Dr. Konzak also has studied the use of induced mutants.[60]

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[52] Olesen's Dwarf was derived from a complex double cross involving a Mexican dwarf (a Pitic sib) crossed into a dwarf plant of unknown origin found in a farmer's field in Rhodesia; the other parent is descended from the Italian variety Mara (*1966–67 Report, CIMMYT*, p. 79; also see Fick and Qualset, *op. cit.*, p. 532). Mara is a descendent of Mentana and Akakomugi.

[53] G.N. Fick and C.O. Qualset, "Genetic Control of Endosperm Amylase Activity and Gibberelic Acid Responses in Standard-Height and Short Statuted Wheats." *Proceedings of the National Academy of Sciences*, Washington, March 1975 (Vol. 72, No. 3), pp. 892–895; letter from Gale, *op. cit.*, March 22, 1978.

[54] *1966–67 Report, CIMMYT*, pp. 78, 79. Further details on the use of these varieties in the hybrid wheat program are provided in the *CIMMYT Report, 1967–68*, pp. 76, 77, and the *CIMMYT Annual Report, 1972*, p. 27. Also see Fick and Qualset, *op. cit.* (1973), pp. 531–532.

[55] *CIMMYT Annual Report, 1972*, p. 27; letter from R. Glenn Anderson, CIMMYT, January 10, 1978; and letters from Gale, *op. cit.*, March 22, April 14, 1978. The full geneology of this variety is uncertain. One scientist suggests that it carries the Tom Thumb gene (letter from S. Rajarm of CIMMYT to Gale, November 8, 1976); another suggests that it does not (letter from Konzak, *op. cit*, April 12, 1978). Gale now has shown it to carry Rht 1 and Rht 2 and not Rht 3 (letter, April 26, 1978).

[56] *CIMMYT Review, 1975*, pp. 52, 53; *CIMMYT Review, 1976*, p. 69; and *CIMMYT Review, 1977*, p. 70.

[57] *CIMMYT Review, 1977*. p. 70. The origins of this variety are somewhat uncertain. CIMMYT variously reports its origins as Korea or Tibet via Japan. There is some thought that it is the Japanese variety, Hitsumi (Hitsumikomugi) which has Norin 39, and Tohoku 56 (Akadaruma x Akakawaaka) as parents. Two key characteristics of Hitsumi are: (a) it is not considered a dwarf in Japan, though it is of short stature when raised in Korea, and (b) it probably does not have a different dwarfing gene than the Mexican varieties (both share Akadaruma ancestry). (Letters from T. Gotoh, *op. cit.*, March 9, 1978, and Chang Hwan Cho, *op. cit.*, March 15, 1978.)

[58] Abbondanza has Mentana and the Japanese variety Akakomugi in its parentage (details on the latter two varieties are provided in Chp. II).

[59] Statement of Haldore Hanson, Director General of CIMMYT at International Centers Week, Washington, D.C., September 13, 1977, p. 9. The Chinese have utilized outside sources of dwarfism: first Suwon 88, and then Tom Thumb, Olesen, and Norin 10 (*Wheat in the People's Republic of China*, National Academy of Sciences, Washington, CSCPRC Report No. 6, 1977, p. 31).

[60] Letters from Konzak, March 13, 1978, March 23, 1978; Konzak, *op. cit.* (1976), pp. 79–91.

HIGH-YIELDING RICE

The origins of the current high-yielding varieties have their roots deep in history and represent a melange of many different efforts and programs.[1]

Chinese Antecedents

China has perhaps the most extended history of rice improvement.[2] As with other countries, much of this was simply farmer selection of improved varieties for local use.

The most significant recorded early step took place sometime before 1000 A.D. when a new group of rices, Champa, was introduced into Fukien from Indochina.[3] After 1012, they were introduced into the lower Yangtze and lower Huai areas. Champa rices had several outstanding features; they were relatively early ripening (60 to 100 days after transplanting) and drought resistant. Although indigenous early ripening rices had been in use previously, they were quickly replaced by the Champa rices.

Following the introduction of Champa varieties, the use of early ripening rice expanded, especially in southeast China. Other shorter season varieties were developed in the 11th and 12th centuries. By the early 1830's, the area under early maturing varieties reportedly exceeded that under traditional types. While most probably were used for early season planting, thereby allowing double-cropping, some were used to plant after severe droughts or floods.[4]

The major types of rice grown in China are indica and japonica (or keng). Indicas traditionally have been raised in southern China, and japonicas have been grown in more northerly locations.[5] Attempts have been made, both in China (see Chapter IV) and in other countries, to improve both types of rice for use in the tropics and other regions.

Japonica Varieties

Breeding of local rices was initiated in Japan early in the 1900's. Successes were obtained in breeding more nitrogen-responsive and disease-resistant types.[6]

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[1] Dr. T. T. Chang of the International Rice Research Institute was of great help in the preparation of this section.

[2] See: Dwight H. Perkins, "Improved Seed," *Agricultural Development in China, 1368–1968*, Aldine, Chicago, 1969, pp. 38–41; Leslie T. C. Kuo, "Seed Selection," *The Technical Transformation of Agriculture in Communist China*, Praeger, 1972, Chp. 9, pp. 143–160.

[3] Dr. T. T. Chang recently has placed the point of origin as central Vietnam ("The Rice Cultures," *Philosophical Transactions of the Royal Society of London*, Series B, July 27, 1976 (Vol. 275, No. 936), p. 148.) Also noted in T. T. Chang in "The Origin, Evolution, Cultivation, Dissemination, and Diversification of Asian and African Rices," *Euphytica*, 1976 (Vol. 25), p. 435.

[4] Ping-ti Ho, "Early Ripening Rice in Chinese History," *The Economic History Review*, December 1956, pp. 200–216. Rice in north China is discussed by Ho in "The Loess and the Origin of Chinese Agriculture," *American Historical Review*, October 1969, pp. 19–26.

[5] T. H. Shen, *Agricultural Resources of China*, Cornell University Press, 1951, p. 197.

[6] Matsuo, *op. cit.* (Chp. I, fn. 17), pp. 20–27, 91–93.

A breeding program to develop daylength- and temperature-insensitive types was initiated in Taiwan in the early 1920's and resulted in the "ponlai" varieties (such as Taichung-65 and Chianan-8).[7] These varieties were early maturing and fertilizer responsive. They made double-cropping of a single variety possible and facilitated intercropping.[8] Between 1925 and 1940, 50 percent of the riceland in Taiwan was shifted to the ponlai varieties; they represented 72 percent of the total area in 1967 and nearly 85 percent in 1976.[9]

Subsequent research verified their high-yielding ability over a wide area in tropical Asia and Africa.[10] But the ponlais did not gain wide commercial acceptance because of disease problems and undesirable grain features.

Japonica x Indica Crosses

An FAO-India program was established in 1950 to cross japonica and indica varieties. Results generally were not satisfactory, because nearly all of the japonica parents were from Japan and were poorly adapted to a tropical climate. But one hybrid, ADT–27, did show a substantial improvement over local varieties and subsequently was planted widely in the Tanjore District.[11] This breeding program also produced a few other varieties. One, Mahsuri (Taichung–65 x Mayang Ebos 80/2), was further developed in Malaysia with Japanese assistance and is now extensively planted.[12] A cooperative project between Korean scientists and the International Rice Research Institute has led to the introduction of Tong–il, a cross between IR–8 and (Yukara x TN–1).[13]

Indica Varieties

Attempts to improve indica varieties in the 1940's and 1950's were moderately successful. Results of this work include H–4 and H–5 in Ceylon and Peta, Sigadis, Bengawan, and Remadja in Indonesia.

Taichung Native 1 (TN–1) was developed in Taiwan, named in 1956, and officially released in 1960. It was obtained by crossing Dee-geo-woo-gen, a short semi-dwarf variety thought to have come from Fukien Province in southern China several hundred years before,[14] with Tsai-Yuan-Chung, a tall drought-

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[7] Several of the ponlai varieties included an indica in their parentage. Details on the development of ponlai varieties are provided in E. Iso, *Rice and Crops in Its Rotation in Subtropical Zones*, Japan FAO Association, Tokyo, 1954, pp. 106–137.

[8] C. H. Huang, W. L. Chang, and T. T. Chang, "Ponlai Varieties and Taichung Native 1," *Rice Breeding*, IRRI, 1972, pp. 31–46; letter from Chang, *op. cit.*, January 6, 1975.

[9] S. C. Hsieh and V. W. Ruttan, " . . . Factors in the Growth of Rice Production. . . ." *Food Research Institute Studies*, 1967 (No. 3), p. 331; *Taiwan Agricultural Yearbook, 1977 Edition*, June 1977, pp. 62, 68.

[10] T. T. Chang, "The Genetic Basis of Wide Adaptability and Yielding Ability of Rice Varieties in the Tropics," *International Rice Commission Newsletter*, December 1967, pp. 4–15.

[11] Background on the Government's program to introduce this variety is provided in Stanley J. Heginbotham, *Cultures in Conflict: The Four Faces of Indian Bureaucracy*, Columbia University Press, 1975, pp. 71–151, 175–186.

[12] Malinja, another variety developed in the same program and planted in Malaysia, represents a cross between two indicas, Siam 29 and Pebifun. Pebifun originally came from Taiwan where it was once a leading variety. (Letter from Chang, October 27, 1970.)

[13] "IR667–98, A Cool Climate Semidwarf," *The IRRI Reporter*, No. 1, 1971, pp. 1–2.

[14] Noted in T. S. Miu (ed.), *A Photographic Monograph of Rice Varieties of Taiwan*, Taiwan Agricultural Research Institute, Special Publication No. 2, December 30, 1959, p. 67.

resistant local variety. It was the first semi-dwarf indica to respond to fertilization as well as or better than the ponlais.[15]

TN–1 had its major impact on rice production in India. Jaya and Padma, subsequent Indian varieties, represent a cross of TN–1 and T–141, a tall Indian variety from Orissa.[16] Through 1973, the Indian Council of Agricultural Research had released a total of 16 high-yielding varieties and a number of others were under trial; the most recent releases as of that year were Sona and Jayanti (both of which had superfine grains).[17] In Thailand, a 1964 cross of TN–1 with a local variety (Gam Pai 15/2) produced RD–2, a glutinous variety grown in the Northeast.

These and other HYV's are listed in table 3.

Breeding work in the Philippines was carried out both by the National Government and IRRI. Among the products of the national program, the best known are:[18]

- *BPI–76.* Derived from a cross between Fortuna and Seraup Besar 15. Developed by the Bureau of Plant Industry in 1957 and released in 1960. Strains having less photoperiod sensitivity, such as BPI–76–1 and BPI–76 (n.s.), were released later.
- *C4–63.* Derived from a cross between BPI-76 and Peta. Developed by the College of Agriculture, the University of the Philippines, in 1962 and released in April 1968. A subsequent selection is known as C4–63G.

The IRRI breeding program began in 1962 and by 1975 released 11 varieties, plus a number of lines which have been named by other agencies and governments (table 3). The major characteristics and resistance ratings of the 11 varieties are outlined in tables 4 and 5. Over time, the varieties have incorporated increased resistance to diseases and insects and greater tolerance to soil problems. Grain quality also has improved.[19]

The IRRI materials have been widely used. A recent survey of 28 experiment stations in 10 Asian nations revealed that 64 percent of the new varieties released by these programs from 1970 to 1975 were either progeny of seed provided by IRRI or were developed at IRRI. More specifically, 42 percent had one or more IRRI parents, while 22 percent were IRRI varieties or lines.[20] Further details on the results of the survey in India are provided in Appendix D of this report.

The genealogy of the first six IRRI varieties is depicted in figure 3. All of the 11 IRRI varieties include Peta in their ancestry.[21] The main dwarfing character-

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[15] See T. T. Chang, *Recent Advances in Rice Breeding in Taiwan,* Joint Commission on Rural Reconstruction, Plant Industry Series 22, 1961, pp. 33–58.

[16] S. V. S. Shastry, "New High-Yielding Varieties of Rice: Jaya and Padma," *Indian Farming,* February 1969, pp. 5–13; Streeter, *op. cit.,* pp. 26, 28.

[17] For details, see: Mahabal Ram, "Ten Years of Dwarf Rice in India," *World Crops,* January/February 1975, pp. 33, 34. Also see *Morphological and Physiological Characteristics of Some High-Yielding Rice Varieties,* IADP Technical Bulletin 9, 1970, 41 pp. (Eluru, India).

[18] Letters from T. T. Chang, January 6, 1975, December 22, 1975.

[19] New problems, however, continue to appear. Recent examples include new biotypes of the brown planthopper and a new disease called ragged stunt or infectious gall disease. Biotype 2 of the brown planthopper attacks some varieties which were resistant to biotype 1 of the brown planthopper. Ragged stunt disease seems to be spread by the brown planthopper. Some of the newer varieties are moderately resistant to both. Details are provided in *The IRRI Reporter,* No. 2, 1977, pp. 1–4.

[20] *Research Highlights for 1976,* IRRI, 1977, p. 53. Further details are provided in *The IRRI Annual Report for 1976,* pp. 137–143 and in the IRRI Research Paper Series: No. 12, January 1978; and No. 13, February 1978.

[21] Peta came from a cross of Tjina (Cina) x Latisail. Tjina is synonymous with China. Latisail came from Bengal. Other varieties produced from the same cross by Indonesian-Dutch breeders in 1940–41 included Mas, Intan, and Bengawan (Z. Harahap, et. al, "Breeding Rice Varieties for Indonesia," *Rice Breeding,* IRRI, 1972, p. 142).

Table 3—HYV Rice Varieties Named From IRRI Lines, Developed From IRRI Crosses by National Programs, or Developed From Crosses Made by National Programs[1]

Country	Variety	Cross or parental line[2]
ASIA (South and East)		
BANGLADESH	Biplab (BR–3)*	IR506 x Latisail
	Brrisail (BR–4)*	IR–20 x IR–5
	Chandina (BR–1)	IR–532 (IR 262 x TKM–6)
	Irrisail	IR–20
	Mala (BR–2)	IR272
	BR–6 (IR–28)	IR1561 x IR1737
	Brribalm (BR–7)	IR1416 x (IR–22 x C4–63)
INDIA[3]	ADT–31*	IR–8 x Culture 340
	Anupama*	SLO–16 x IR–8
	Aswini* (Aswathi)	PTB10 x DGWG
	Bala*	N22 x TN–1
	Bharathi*	PTB10 x IR–8
	Bhavani*	Peta x BPI–76 (same cross as C4–63)
	Cauvery*	TN–1 x TKM–6
	CNM25*	IR–8 mutant
	CO–33*	IR–8 x ADT–27
	CO–34*	TN–1 x CO–29
	CO–39*	Culture 340 x Kannagi
	CR34–16*	TN–1 x TKM–6
	CR36–148* (Supriya)	IR–8 x (G.E.B. 24 x TN–1)
	Hamsa*	HR12 x TN–1
	HM95*	Mutant of Jhona 349 x TN–1
	IET 1039*	T90 x IR–8
	'IR50'	IR442
	'IR58'	IR442
	Jagannath*	Mutant from T141
	Jamuna*	Bas. 370/5 x TN–1
	Jaya*	TN–1 x T141
	Jayanti*	T90 x IR–8
	Jyothi*	Ptb 10 x IR–8
	K78*	Shin-ei x Chin 971
	K84	T65 mutant
	Kalinga 1 & 2*	Dunghanshali x IR–8
	Kannagi	IR–8 x TKM 6
	Karjat 14–7*	IR–8 x Ziniya 149
	Krishna*	GEB24 x TN–1
	OR34–16*	TN–1 x TKM–6
	Padma*	T141 x TN–1
	Palman 579	IR579 from IR–8 x Tadukan
	Pani Dham 1	IR442
	Pani Dham 2	IR442
	Pankaj	IR5–114–3
	Ponni*	(Mahsuri)
	Pusa 2–221* (Kannagi)	IR–8 x TKM–6
	Ratna*	TKM6 x IR–8
	Rohini*	PTB10 x IR–8
	RP4–14*	T90 x IR–8
	Sabarmati*	TN–1 x Bas. 370/5
	Sabari	IR–8 x (TN–1 x PTB10)
	Sona*	GEB24 x TN–1
	Suma*	TN–1 x TKM–6
	Tella Hamsa*	HR12 x TN–1
	Triveni*	Annapoona x PTB15
	Vaigai*	TN–1 x CO–29
	Vani	IR–8 x CR1014
	Viijaya*	T90 x IR–8
INDONESIA	Pelita 1/1*& Pelita 1/2*	PB5 (IR–5) x Syntha
KOREA (SOUTH)	Tongil	IR667 from IR–8 x (Yukara x TN1)
	Yushin	Tongil x IR1317
	Milyang 21, 22, and 23*	IR1317–316–5–2 x IR–24
	Milyang 15*	Norin 6 x Chugoku 46

[1] Varieties developed from crosses made by national programs are marked by *
[2] Maternal parent listed first in crosses.
[3] Does not include all varieties released at the state level.

Country	Variety	Cross or parental line[2]
MALAYSIA	Bahagia	IR–5–278
	Mahsuri*	(Taichung 65 x Mayang Ebos 80) x M.E. 80
	Malinja*	Siam 29 x Pebifun
	Murni*	Bahagia x IR–8
	Padi Jaya*	Peta x BPI 76 (same cross as C4–63)
	Pulut Malaysia Satu*	Pulut Sutera x Ria (IR80)
	Sri Malaysia Satu (1)	IR5–250
	Sri Malaysia Dua (11)	IR–8 x Pankhari 203
NEPAL	Parwanipur 1	IR400 from Peta/4 x TN1
PAKISTAN	Abbasi–72	IR841–36–2
	Mehran 69	IR–6 line from Siam 29 x DGWG
	IR841	(Peta3 x TN–1) x KDM 105
PHILIPPINES	BPI–12*	BE3–37–5 (mutant) x IR–20
	BPI–76*	Fortuna x Seraup Besar 15
	BPI–76 (NS)*	selected from BPI–76
	C4 (C4–63)*	Peta x BPI–76
	C4–137*	Peta x BPI–76
	C–168*	Intan x BPI–76
SRI LANKA	BG3–5*	(Panduruwi x Mas) x Engkatek
	BG11–11*	(Engtatek x H–8) x H–8
	BG34–6*	IR–8 x [(PP2462/11 x Mas) x H–501]
	BG34–8*	IR–8 x [(PP x Mas) x H501]
	BG90–2*	IR262 x Ramadia
	BG94–1*	IR262 x LD66
	BG96–2*	[IR–8 x (Peta/5 x Belle Patna)] x BG66–1
	IR262	Peta/3 x TN–1
	IR–532	IR262 x TKM–6
	LD 66*	H–501 x DGWG
	LD125*	IR262 x H–7
	PD106–1*	Warangal 1263 x IR8/3
TAIWAN	Chainung-sen 6*	IR–8 x TKM–6
	Chainung-sen 8	IR661
	Chainung-sen 11* & 12*	IR–8 x IR9–60
THAILAND	RD1*, RD3*	IR–8 x Leuang Tawng
	RD 2	Gam Pai 15/2 x TN–1
	RD4*	Leuang Tawng/IR–8 (17–1)//W1252///RD2
	RD5*	Paung Nahk 16 x Sigadis
	RD7*	Gow Ruang 88/C4–63//Sigadis SPR6726–134–2–26
	RD9*	TN–1 2/Leuang Yai 34 (CNT 3176)//W1256 ///RD2 BNK 6809–74–40
VIETNAM (SOUTH)	TN73–1	IR1529 from (Sigadis/2 x TN–1 x IR–24)
	TN73–2	IR1561 from (IR–8 x Tadukan) x TKM–6/2 x TN–1
NEAR EAST (West Asia, North Africa)		
EGYPT	Sakha 1	IR579
	Sakha 2	IR1561
IRAN	Amol 1*	(Tarom Firoze x Kanda) x TN–1
	70/53*	Dumsiah x IR–8
AFRICA (excluding North Africa)		
IVORY COAST	CS–1	IR262 from Peta/3 x TN–1
	CS–2	IR160 from Nahng Mon S–4 x TN–1
	CS–3	IR253 from Gam Pai 15/2 x TN–1
	CS–5	IR506
	CS–6	IR480
SIERRA LEONE	ROK–6	IR5
LATIN AMERICA		
BRAZIL	IR665 (?)[4]	IR–8 x (Peta/5 x Belle Patna)
	IR841 (?)[4]	IR262 x Khao Dawk Mali 4–2–105
COLOMBIA[5]	CICA 4	IR930 from IR–8 x IR12
	CICA 6	IR930 x IR822
	CICA 7	IR–22 x (IR 930 x Colombia 1)
	CICA 9	IR–665 x (IR 841 x C46–15)
COSTA RICA	CR1113	IR822 from (IR8/2 x Pankhari 203)

[4] Uncertain about local variety name.

[5] The geneaology of the CICA varieties is presented graphically in Peter R. Jennings, "The Amplification of Agricultural Production," *Scientific American*, September 1976, p. 183.

Country	Variety	Cross or parental line[2]
DOMINICAN REPUBLIC	Advance 72	IR930 (CICA–4)
ECUADOR	INIAP–2	IR–22
	INIAP–6	IR930 (CICA–4)
EL SALVADOR	Nilo 9	IR160
	Nilo 11	IR579 from IR–8 x Taduken
GUYANA	G, J and R	IR1052 cross from BG–79 x IR–8
	K and S	IR1055 cross from BG–79 x IR400
	T*	BG60/283
MEXICO	Bomoa	IR837 (IR262 x N.S.P.T.)
	Macuspano A 75	(Venus A68 x Peta) x T. Rotan
	Navolato A–71	(Sister of IR–22)
	Piedras Negras A74	IR837 (IR262 x N.S.P.T.)
	Sinaloa A68	IR160 from Nahng Mon S–4 x TN–1
	Joachin A–74*	(Corerepe A66/3 x TN–1) x IR160
	Juchitan A–74	(B572–A3–47–15) x B589–A4–18–1)
PERU	Chancay	IR930 from IR–8 x IR12
	Naylamp	IR930 (CICA–4)
	Huallaga	(Peta/2 x TN–1) x Leb Mue Nahng

Source: Unpublished table compiled by T.T. Chang and associates, International Rice Research Institute, February 23, 1976. Dr. Chang indicates that not all of the varieties may be of commercial importance. The listing reproduced here excludes some varieties, used in several South Pacific islands, which were included in the original list. Partially updated with information provided by T.R. Hargrove and W.R. Coffman of IRRI, February and March 1978, R. Seetharaman of the All India Coordinated Rice Improvement Project, March and April 1978, and other sources.

Table 4—Major Characteristics of Varieties Named by IRRI

Character	IR-8	IR-5	IR-20	IR-22	IR-24	IR-26	IR-28	IR-29	IR-30	IR-32	IR-34
Growth duration											
Dry season (Dec. seeding)	125 days	135 days	120 days	115 days	125 days	130 days	105 days	115 days	106 days	140 days	120 days
Wet season (June seeding)	130 days	145 days	135 days	130 days	125 days	130 days	105 days	115 days	109 days	145 days	125 days
Sensitive to photoperiod	no	weakly	weakly	weakly	no	no	no	no	no	no	no
Grain											
Length	medium	medium	medium	long	long	medium	long	medium	medium	long	long
Width	bold	bold	slender	slender	slender	slender	slender	slender	slender	slender	slender
Appearance	some white belly	some white belly	translucent	translucent	translucent	translucent	translucent	opaque	translucent	translucent	some white belly
Head rice recovery	low	moderate	high	high	high	high	high	high	high	high	high
Amylose content	high	high	moderately high	high	low	high	high	waxy	high	high	high
Gel consistency	high	low	medium	high	low	medium-low	high	low	low	low	high
Gelatinization temperature	low	intermediate	intermediate	low	low	low	low	low	intermediate	low	low
Seed dormancy	moderate	moderate	moderate	moderate	moderate	moderate	moderate	moderate	moderate	moderate	high
Seedling vigor	very good	very good	very good	good	good	good	good	very good	very good	very good	very good
Height	90-105 cm	130-140 cm	110-115 cm	95-105 cm	100-110 cm	100-110 cm	100-110 cm	90-100 cm	95-105 cm	100-110 cm	120-130 cm
Tillering ability	high	high	high	high	moderate	high	moderate	high	high	high	high
Lodging	resistant	moderately resistant	moderately resistant	resistant	resistant	moderately resistant	moderately resistant	moderately resistant	moderately resistant	resistant	moderately resistant

Source: *The IRRI Reporter*, No. 4, 1975.

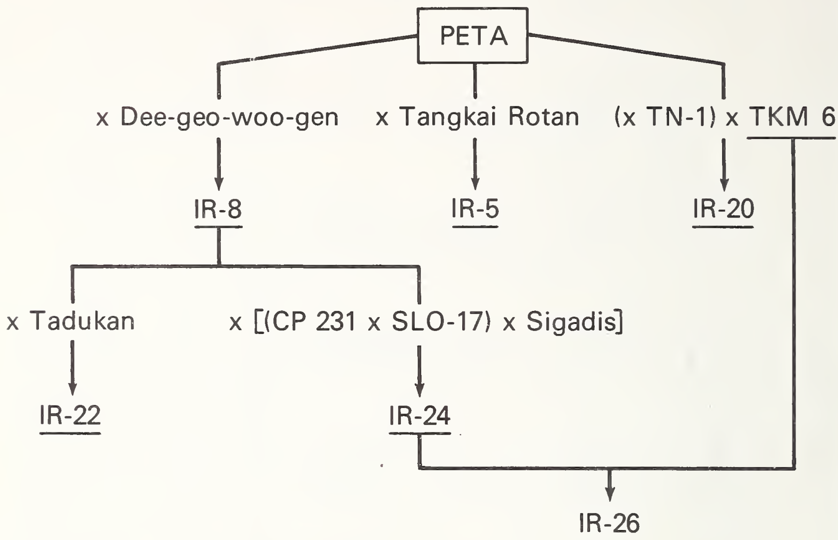
Table 5—Resistance Ratings of IRRI Varieties*

	Diseases				Insects				Soil problems			
Variety	Blast	Bacterial blight	Grassy stunt	Tungro	Green leaf-hopper	Brown plant-hopper	Stem borer	Gall midge**	Alkali injury	Salt injury	Zinc deficiency	Phosphorus deficiency
IR-8	MR	S	S	S	R	S	MS	S	S	MR	S	MR
IR-5	S	S	S	S	R	S	S	S	S	MR	R	MR
IR-20	MR	R	S	R	R	S	MR	S	S	MR	R	R
IR-22	S	R	S	S	S	S	S	S	S	S	S	MR
IR-24	S	S	S	MR	R	S	S	S	MR	MR	S	MR
IR-26	MR	R	MS	R	R	R	MR	S	MR	MR	S	R
IR-28	R	R	R	R	R	R	MR	S	MR	MR	R	R
IR-29	R	R	R	R	R	R	MR	S	S	MS	R	R
IR-30	MS	R	R	R	R	R	MR	S	MR	MR	R	MR
IR-32	MR	R	R	R	R	R	MR	R	S	—	—	—
IR-34	R	R	R	R	R	R	MR	S	S	S	R	R

R = resistant MR = moderately resistant MS = moderately susceptible S = susceptible

*Rated in the Philippines.
**Rated in India.
Source: *The IRRI Reporter*, No. 4, 1975.

Figure 3—Genealogy of Early Semi-Dwarf IRRI Rice Varieties[1]



[1] *The genealogy of some varieties has been simplified slightly for graphic purposes.*

istic, however, is provided by Dee-geo-woo-gen. Dee-geo-woo-gen was included in the ancestry of 10 of the 11 IRRI varieties (it was one of the parents of TN–1); IR–5 was the only exception, and it was the tallest of the group (130–140 cm.). Additional notes on the 11 IRRI varieties follow.[22]

IR–8 was the first of the IRRI semi-dwarf varieties. The initial cross was made in 1962, and the variety was released in November 1966.[23]

IR–5 was developed concurrently and was released in December 1967. It was moderately tall—the tallest of the IRRI varieties.[24]

IR–20 and IR–22 were named in December 1969. Both represented an improvement in grain quality over IR–8 and IR–5.[25]

IR–24 was named in May 1971. It has a low amylose level, meaning that the rice cooks soft and moist.[26]

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[22] In listing the IRRI varieties here and in the remainder of the report, a dash has been inserted between IR and the varietal number to maintain consistency with other varietal designations and to improve recognition. IRRI itself does not include this dash in its own publications. Dashes are not inserted in the designation of test lines.

[23] For details, see Robert F. Chandler, "Dwarf Rice-A Giant in Tropical Asia," *1968 Yearbook of Agriculture*, pp. 252–255; Streeter, *op. cit.*, pp. 26–29.

[24] Further information is provided in "IR–5–A New High-Yielding IRRI Variety," *IRRI Reporter*, January 1968, 4 pp.

[25] The additional information is found in "IR–20 and IR–22, New Rice Varieties," *The IRRI Reporter*, January 1970, 4 pp.

[26] Further details are presented in: "IR–24–A Low Amylose Variety," *The IRRI Reporter*, No. 2, 1971, pp. 1–2; and the *IRRI Annual Report for 1971*, p. 182.

IR–26 was released in November 1973. It had significantly improved resistance to diseases and insects. The eating quality was slightly better than IR–20.[27]

IR–28, IR–29, and IR–30 were released in January 1975. They are early maturing and have improved resistance ratings. IR–29 is the first IRRI variety to have a glutinous or waxy grain; this type of rice cooks soft and sticky, is the staple food in Laos and northeast Thailand, and is used in special preparations such as cakes and pastries across Asia.[28] The parentage of these varieties is:

- IR–28 and IR–29: Peta^{3}//TN–1/Gam Pai 15/4/IR–8/Tadukan//TKM–6^{2}/TN–1///IR–24^{4}/*Oryza nivara*.
- IR–30: IR–24/TKM 6//IR–20^{3}/*Oryza nivara*.

IR–32 and IR–34 were released in July 1975. They have some characteristics which may adapt them to rainfed areas where the previous IRRI varieties were not as well suited. This is desirable in some regions, where farmers grow only one crop, so that harvesting and drying can be done after the monsoon rains. IR–32 matures later (140 to 145 days) than the other IRRI semidwarfs. IR–34 is intermediate in height and may be suited for regions where water becomes rather deep for semi-dwarfs during the monsoon seasons. Both have improved disease and insect resistance, but are less tolerant of certain soil problems.[29] The parentage of these varieties is:

- IR–32: IR–20^{2}/*Oryza nivara*//*CR 94–13*.
- IR–34: *Peta^{3}/TN–1//Gam Pai 15/4//IR–8/Tadukan///TKM 6^{2}/TN–1////IR–2464/Oryza nivara*

As of November 1975, IRRI stopped its practice of naming varietal releases. Instead, the naming of varieties will be left to national organizations and programs.[30]

In the Philippines, the Philippines Seed Board continues to use the IR designation for IRRI selections released in that country. As of mid-1978, five varieties had been so named: IR–36 (1976), IR–38 (1976), IR–40 (1977), IR–42 (1977), and IR–44 (1978). IR–36 and IR–42 are sisters, as are IR–38 and IR–40 (which are sisters of IR–32). Their parentage is:[31]

- IR–36 and IR–42: IR 1561–228–1–2//IR–24^{4}/*Oryza nivara*///CR 94–13.
- IR–38 and IR–40: IR–20^{2}/*Oryza nivara*// CR 94–13. (Same parents as IR–32.)

Despite their similar parentage, IR–36 and IR–42 have, as is usually the case with siblings, both similarities and differences. They are similar in that both are resistant to biotypes 1 and 2 of the brown planthopper. IR–36 has several additional special characteristics: early maturity (110 days), considerable insect and disease resistance, drought tolerance, and is capable of high yields. Special characteristics of IR–42 include high yield potential in the wet season at all levels of nitrogen and very good seedling vigor.

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[27] Further details are provided in "IR–26 is Resistant to Brown Planthoppers," *The IRRI Reporter*, No. 4, 1973, pp. 1–2.

[28] "IRRI Names Three Early Maturing Rices with Disease and Insect Resistance," *The IRRI Reporter*, No. 1, 1975, pp. 1–3. The parentage of IR–28 and IR–29 is presented graphically by Gurdev S. Khush, "Breeding for Resistance in Rice," in Peter R. Day (ed.), *The Genetic Basis of Epidemics in Agriculture*, New York Academy of Sciences, Annals, Vol. 287, February 1977, p. 302.

[29] "IRRI Names Two New Rice Varieties," *The IRRI Reporter*, No. 4, 1975, pp. 1, 4. The parentage of IR–34 is presented graphically by Khush, *op. cit.*

[30] "IRRI Announces New Policy on Naming of Rice Varieties," *The IRRI Reporter*, No. 1, 1976, p. 1.

[31] The information presented here and below was provided by Reeshon Feuer, T.T. Chang, and W.R. Coffman, all of IRRI.

IR–38 and IR–40 have somewhat less resistance to biotype 2 of the brown planthopper. IR–38 has high yield potential, very good eating quality and very good seedling vigor. IR–40 has whorl maggot resistance and high milling recovery: it is suggested for dry season use.

Clearly, plants with a wide range of characteristics and crosses have been developed from a few original varieties. More are currently under development and will appear in the future. IRRI scientists now see the major future challenges as twofold: (1) pest management in intensive irrigated areas, and (2) creating technology suitable to the low-input rainfed areas.[32]

The specific wheat and rice varieties which have been outlined in this chapter will reappear in the footnotes of many of the country tables in the next two chapters. It is not possible to obtain a complete varietal breakdown for each country, but such information is included where reported.

Sources of Dwarfism and Cytoplasm

All of the *semi-dwarf* (80 to 120 cm.) rice varieties in use in the non-Communist developing nations derive their major dwarfing gene from Dee-geo-woo-gen (DGWG). The situation is quite different for *intermediate* varieties (120 to 140 cm.), which appear to have a much more diverse ancestry.

IRRI scientists have been concerned with the need to broaden the sources of dwarfism for some time. A number of varieties have been examined but none have yet proven useful.[33] For a while, it seemed that the People's Republic of China (PRC) might provide additional sources of dwarfism (see Chp. IV, PRC), but it now appears that the Chinese semi-dwarf varieties deriving either from Ai-tse-chuan or Ai-chiao-nan-te have the same dwarfing gene as DGWG.[34]

A somewhat similar situation is found with cytoplasm. Cytoplasm carries certain genetic traits which are inherited maternally. All of the IRRI varieties have a similar maternal ancestry (Cina via Peta).[35] Many of the varieties developed in national programs also have a similar maternal lineage. IRRI is now gathering further data on the nuclear and cytoplasmic composition of nationally developed varieties.[36]

As noted in the wheat section, there are well-known perils in having a narrow genetic base. Hence, it would seem that efforts should be intensified to find other useful sources of dwarfism and new maternal parents.

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[32] Randolph Barker and Robert W. Herdt, "The World Rice Situation, 1977–79," IRRI, December 1977, 9 pp.

[33] T.T. Chang and B.S. Vergara, "Ecological and Genetic Information on Adaptability and Yielding Ability in Tropical Rice Varieties," in *Rice Breeding*, IRRI, 1972, pp. 441–443, 450. Reports of IRRI studies of dwarfing sources by Dr. T.T. Chang *et al.* are provided in the *IRRI Annual Report for 1971* (pp. 199–200), *1973* (p. 161), and *1976* (pp. 25–26). The latter publication suggested that the Chi-nan-ai variety from the PRC (mislabeled as Cheng-nan-ai in earlier tests) is "genetically different" from TN–1, but that "because of its variable plant height and growth duration, its potential as a semidwarfing source appears limited." Further information on IRRI investigations will appear in the forthcoming IRRI *Annual Report for 1977*.

[34] Unpublished information provided by Dr. T.T. Chang.

[35] Based on unpublished materials provided by W.R. Coffman and T.R. Hargrove of IRRI, January to March 1978.

[36] Coffman and Hargrove discuss many of these matters in much greater detail in a forthcoming paper entitled "Genetic Diversity of Modern Rice Varieties: A Preliminary Report." (A draft was presented at the International Rice Research Conference, IRRI, April 17–21, 1978.)

III. HIGH-YIELDING WHEAT VARIETIES

This chapter summarizes available data on the area of high-yielding varieties of wheat planted or harvested and fragmentary information on seed imports by developing nations in Asia (South and East), the Near East (West Asia and North Africa), Africa, and Latin America. Separate tables are provided for most of the Asian and Near Eastern countries. The national data for other regions generally are summarized in brief notes.

The tables provide annual data on major seed imports and the HYV area planted or harvested. Further details are presented in footnotes. A reference is provided for each statistic cited. Data which are particularly tentative or are preliminary estimates for 1977/78 are placed in parentheses. Statistics generally are rounded to the nearest hundred; consequently, the hectare and acre figures do not convert precisely.

The parentage of many of the varieties mentioned in this chapter is summarized in table 1 in Chapter II. Parentages also are provided in Anton C. Zeven, *Genealogies of 14,000 Wheat Varieties* (CIMMYT, 1976, 121 pp.); and B. Skovmand and S. Rajaram, *Semidwarf Bread Wheats: Names, Parentage, Pedigrees, Origin* (CIMMYT, Information Bulletin No. 34, 1978, 16 pp.). Details on the breeding programs in many of the countries are presented in the annual *CIMMYT Report on Wheat Improvement* (1973 to the present).

Semi-dwarf wheat has been raised in a number of developed countries. In the United States, a relatively short-strawed (but not semi-dwarf), earlier maturing wheat was first introduced in 1794 (Chapter II), and again in 1940.[1] The first semi-dwarf variety, Gaines, was developed from a Norin 10 x Brevor cross by Dr. O. A. Vogel (Chapter II) and released in 1961. Other semi-dwarf varieties subsequently were released in several States, and Mexican varieties were introduced.[2] By 1970, significant areas were planted to semi-dwarfs in five Western States.[3] By 1975, the semi-dwarf area in this region increased even more and two North Central States were added: North Dakota and Minnesota.[4] Altogether, perhaps one quarter or more of the U.S. wheat area was planted to

[1] L. W. Briggle and O. A. Vogel, "Breeding Short-Stature, Disease-Resistant Wheat in the United States," *Euphytica*, Supplement No. 1, 1968, p. 108.

[2] *Ibid.*, pp. 110, 114–125; L. P. Reitz and S. C. Salmon, "Origin, History, and Use of Norin 10 Wheat," *Crop Science*, November-December 1968, pp. 686–687. While most of the varieties trace this dwarfing characteristic to Norin 10, Suwon 92 (discussed in Chp. II, fn. 48) also has been used.

[3] L. P. Reitz, K. L. Lebsock, and G. D. Hasenmyer, *Distribution of the Varieties and Classes of Wheat in the United States in 1969*, U.S. Department of Agriculture, Agricultural Research Service, Statistical Bulletin No. 475, May 1972, pp. 14, 15. Also see L.P. Reitz, *Wheat in the United States*, U.S. Department of Agriculture, Agricultural Research Service, Information Bulletin No. 386, February 1976, pp. 10, 11, 14. The semi-dwarfs probably accounted for over 75 percent of the area in Arizona and California in 1970 and over 50 percent in Oregon, Washington, and Idaho. Additional areas were planted to short varieties in other States.

[4] Based on phone discussions with wheat breeders in a number of States. Virtually all of the wheat area in Arizona and California was believed to be planted to semi-dwarfs, while the percentages in other States were about as follows: Oregon 70; Washington, 75; Idaho, 70; North Dakota, 30; Minnesota, 80.

semi-dwarfs in 1975.[5] Further expansion is likely. No attempt has been made to detail such progress in the developed nations in this report.[6]

ASIA

HYV wheat has found major adoption in South Asia, particularly in India and Pakistan. It also is raised in Nepal. The area in Bangladesh is limited but is expanding rapidly. Most of the land sown to the HYV's in South Asia is irrigated to some degree.

The HYV wheat area in non-Communist East Asian LDC's, where wheat is of minor overall importance compared to rice, appears to be negligible. Burma imported some 1.5 metric tons (M.T.) of Indian HYV seed in 1969/70, but it is not known what came of it. Japan, the home of Norin 10 wheat, is excluded from this report because of its status as a developed nation.

Both North Vietnam and the People's Republic of China (PRC) have imported significant quantities of HYV seed. North Vietnam imported 1,000 M.T. of Sonalika seed from India in 1972/73. The PRC's imports of Mexican seed are discussed separately in this section. Mongolia also imported small quantities of Indian seed in 1974/75 and 1975/76.[1]

South Korea.—Korea has been a relatively small producer of wheat, but is intending to increase production in order to reduce imports. A Wheat and Barley Research Institute was established in 1977. The Mexican varieties have not proven to be well suited to the Korean climate and to growing conditions. Korea, however, has a relatively good genetic base to draw on. A number of semi-dwarf varieties have been developed which trace their ancestry back to the Daruma varieties of Japan (see Chp. II). Two of the better-known varieties developed in the 1930's are Suweon 92 and Seu Seun 27 (see Chp. II., fn. 48). Recently, several new varieties were released:

—Chokwang (1975): Jackwang × Norin 72.
—Suweon 215, Suweon 216 (1977): Strampelli x Chokwang/69D-3607 (from U.S.)
—Milyang 5 (1977): Norin 72 × Norin 12.

Chokwang and the Suweon varieties were, as of 1977, being multiplied for release to farmers.[2]

[5] Based on discussion with James Naive, Economic Research Service, U.S. Department of Agriculture, February 1976. The inclusion of short-strawed varieties in other States would raise the figure even higher.

[6] The genealogy of some British semi-dwarf varieties is provided by Michael D. Gale and G. A. Marshall in "A Classification of the Norin 10 and Tom Thumb Dwarfing Genes in Hexaploid Bread Wheat." *Proceedings of the Fifth International Wheat Genetics Symposium*, New Delhi, 1978, figure 2 (in press).

[1] Data on seed imports from India provided by Robert C. Tetro, Jr., Assistant Agricultural Attaché, American Embassy, New Delhi, November 28, 1975.

[2] Based on: Letters from Chang Hwan Cho, Chief, Wheat Breeding Division, Wheat and Barley Research Institute, Office of Rural Development, Suweon, December 10, 1977, January 10, 1978; "Current Wheat and Barley Production and Research in Korea," Office of Rural Development (1977), pp. 1–16.

Table 6—Bangladesh: HYV Wheat

Crop year	Quantity of seed imported		Area planted or harvested		
	Metric tons		*Hectares*	*Acres*	
1967/68			1,200	3,000	(3)
1968/69	—		8,500	21,000	(3)
1969/70	—		9,300	23,000	(3)
1970/71	—		13,400	33,000	(3)
1971/72	—		15,000	37,000	(3)
1972/73	50 [1]	(1)	21,450	53,000	(3)
1973/74	1,000 [2]	(1)	29,100	72,000	(3)
1974/75	320 [3]	(1)	33,200	82,000	(3)
1975/76	4,075 [4]	(1)(2)	107,700	266,100 [6]	(3)(4)
1976/77	500 [5]	(1)	116,600	288,000	(3)(5)
1977/78	2,971	(5)	(161,900)	(400,000) [7]	(3)(5)

[1] Kalyan Sona from India.
[2] 700 M.T. of Sonalika and 300 M.T. of Kalyan Sona from India.
[3] 150 M.T. of Sonalika and 170 M.T. of Kalyan Sona from India.
[4] 2,775 M.T. of Sonalika from India; 1,200 M.T. of Tanori 71 from Mexico; and 100 M.T. of foundation seed (40 tons of Tanori 71, 30 tons of Jupa Tico, and 30 tons of Nuri) from Mexico (provided by FAO).
[5] Imported from India in 1976.
[6] "Assessed" area (see ref. 4 below). Officially reported area was 92,200 ha. (227,700 acres). Distributed by province, as follows (in percent): Khulna, 28.4; Chittagong, 28.2; Rajshahi, 27.4; and Dacca, 16.0.
[7] Preliminary.

References

(1) Tables provided by Robert C. Tetro, Assistant Agricultural Attaché, American Embassy, New Delhi, November 28, 1975, February 6, 1978. (Data provided by National Seeds Corporation.)

(2) Shafial Alam, "Notes on the HYV Wheat and Rice," Office of Agricultural Attaché, American Embassy, Dacca, December 1975.

(3) Edward J. Clay, "Ten Years of Dwarf Wheat Production in Bangladesh," Agricultural Development Council, Dacca, March 1978, p. 16, table 3 (draft). Similar data for 1974/75 and previous years are provided by Clay and Stephen D. Biggs in "Wheat in Bangladesh; An Economic Analysis of Past, Present and Future Development," Ford Foundation and the Agricultural Development Council, Dacca, August 1975, table A2.

(4) *HYV Task Force Reports, 1974–75 and 1975–76*, Bangladesh Agricultural Development Corporation, Dacca, December 1976, p. 105, table 1 (enclosure to FAS Report BD 7006 from Dacca, February 8, 1974).

(5) Department of State Telegrams from Dacca: 1079, February 23, 1978; 1659, March 17, 1978.

Table 7—India: HYV Wheat[1]

Crop year	Quantity of seed imported		Area planted or harvested		
	Metric tons		*Hectares*	*Acres*	
1965/66	250 [2]	(1)(2)	3,000	7,400	(3)
1966/67	18,000 [3]	(1)(2)	540,000	1,336,600 [4,5]	(4)
1967/68	—		2,942,000	7,269,700 [4,5]	(4)
1968/69	—		4,792,700	11,842,800 [4,5]	(4)
1969/70	—		5,004,900	12,367,200 [4]	(4)
1970/71	—		6,542,500	16,166,400 [4]	(4)
1971/72	—		7,858,100	19,417,500 [4]	(4)
1972/73	—		10,007,000	24,727,300 [4,6]	(5)
1973/74	—		10,911,500	26,962,300 [4,6]	(6)
1974/75	—		11,215,600	27,713,600 [4,6]	(6)
1975/76	—		13,458,000	33,254,700 [4,7]	(7)
1976/77	—		14,696,000	36,313,800 [4,7]	(7)
1977/78	—		(15,000,000)	(37,065,000) [8]	(7)

[1] See Chapter II (wheat) for a discussion of the evolution of Mexican varieties in India.
[2] 200 M.T. of Sonora 64 and 50 M.T. of Lerma Rojo 64.
[3] Mostly Lerma Rojo 64; remainder, Sonora 64.
[4] The distribution of this area by State was:

	Uttar Pradesh	Punjab	Bihar	Haryana	Other	Total
			Percent			
1966/67	67.1	10.9	4.6	2.5	14.9	100
1967/68	53.9	21.7	6.2	3.4	14.8	100
1968/69	52.5	21.1	6.3	5.4	14.7	100
1969/70	32.8	30.0	8.7	8.8	19.7	100
1970/71	29.6	24.3	13.5	9.6	23.0	100
1971/72	28.0	21.6	15.4	10.1	24.9	100
1972/73	31.4	18.5	16.1	9.8	24.2	100
1973/74	30.8	18.1	15.1	9.3	26.7	100
1974/75	37.0	17.4	7.9	8.8	28.9	100
1975/76	32.9	15.1	12.8	7.7	31.5	100
1976/77	32.0	15.0	12.2	7.3	33.5	100

*Estimated achievement.

[5] Includes improved local varieties (ref. 8 below).
[6] Most popular varieties include Kalyansona and Sonalika. CIMMYT has indicated that as of 1973, Kalyansona accounted for about 48 percent of the HYV area and Sonalika for about 22 percent; other major varieties were Chhoti Lerma, Safred Lerma, U.P. 301, and Lerma Rojo 64A (ref. 9).
[7] Preliminary.
[8] Target.

References

(1) *Rice and Wheat in India,* Spring Review (AID), March 10, 1969, p. 7.
(2) *Five Years of Research on Dwarf Wheat,* Indian Agricultural Research Institute, New Delhi, 1968, Preface; Grant Cannon, "On the Eve of Abundance," *Farm Quarterly,* Fall Forecast, 1967, pp. 89–90.
(3) *1966/67 CIMMYT Report,* p. 67.
(4) Foreign Agricultural Service Report IN–5027 from New Delhi, May 14, 1975.
(5) Data provided by Ivan E. Johnson, Agricultural Attaché, American Embassy, New Delhi, January 2, 1976.
(6) Foreign Agricultural Service Report IN–7037 from New Delhi, May 13, 1977.
(7) Data provided by Robert C. Tetro, Assistant Agricultural Attaché, American Embassy, New Delhi, February 6, 1978 and March 3, 1978. (Data from *Fertilizer Statistics, 1976–77,* Fertilizer Association of India, December 1977, pp. II–78 to II–84.)
(8) V. S. Vyas, *India's High Yielding Varieties Programme in Wheat, 1966–67 to 1971–72,* CIMMYT, 1975, pp. 5, 7.
(9) *CIMMYT Review, 1975,* p. 94.

Table 8—Nepal: HYV Wheat

Crop year	Quantity of seed imported		Area planted or harvested		
	Metric tons		*Hectares*	*Acres*	
1965/66	—		1,400	3,500 [8]	(1)
1966/67	38 [1]	(1)	6,600	16,200 [9]	(1)
1967/68	450 [2]	(1)	24,800	61,300 [10]	(1)
1968/69	7 [3]	(2)	53,800	132,900 [11]	(2)
1969/70	300 [4]	(2)	75,500	186,600 [11]	(2)
1970/71	136.5 [5]	(2)	98,200	242,700 [11]	(2)
1971/72	1,200 [6]	(3)	115,900	286,450 [11]	(3)
1972/73	1,638 [7]	(3)	170,300	420,700 [12]	(3)
1973/74	—		206,800	511,000 [12]	(4)
1974/75	—		246,900	610,000 [12]	(4)
1975/76	—		233,500	577,000 [13]	(5)
1976/77	—		254,200	628,200 [13]	(5)

[1] Lerma Rojo. Imported from Mexico by India.
[2] Lerma Rojo, from India.
[3] S–331 from India.
[4] S–227 from India.
[5] 136 M.T. of S–227 from India and 0.52 M.T. Chenab-70 from Pakistan.
[6] 950 M.T. of S–227; 100 M.T. of RR–21; and 150 M.T. of S–331. All from India.
[7] 915 M.T. of RR–21; 300 M.T. of RR–21 foundation seed; 390 M.T. of S–227; 30 M.T. of UP 301; and 3 M.T. of S–331. All from India.
[8] Lerma 52.
[9] Lerma 52 (91.4 percent) and Lerma Rojo (8.6 percent).
[10] Lerma 52 (31.6 percent) and Lerma Rojo (29.7 percent).
[11] All improved wheat planted.
[12] Kalyansona, RR–21, LR–52, LR–64, S-227, S–331, and UP–301.
[13] Same varieties as listed in fn. 12, plus NL–30 and HD 1982.

References

(1) Department of State Airgram TOAID A–404 from Kathmandu, February 16, 1968.
(2) Letter from Raymond E. Fort, Food and Agriculture Division, USAID Kathmandu, October 13, 1971 (data from Economic and Planning Division, Ministry of Food and Agriculture).
(3) Letter from Philip D. Smith, Chief, Food and Agriculture Division, USAID, Kathmandu, October 17, 1973 (seed import data from the Agricultural Marketing Corporation; HYV area from Department of Agriculture).
(4) Letters from John R. Wilson, Chief, Office of Agriculture, USAID, Kathmandu, October 9, 1975, February 25, 1976 (data from Department of Agriculture).
(5) Letter from Wilson, January 31, 1978 (data from Department of Agriculture).

Table 9—Pakistan: HYV Wheat

Crop year	Quantity of seed imported	Area planted or harvested		
	Metric tons	*Hectares*	*Acres*	
1965/66	350 [1] (1)(2)	4,900	12,000	(1)
1966/67	50 [2] (1)(2)	101,200	250,000	(1)
1967/68	42,000 [3] (1)(2)	957,100	2,365,000	(3)
1968/69	—	2,387,700	5,900,000	(4)
1969/70	—	2,681,500	6,626,000 [5]	(5)
1970/71	—	3,128,300	7,730,000	(6)
1971/72	—	3,286,200	8,120,000 [6,7]	(6)
1972/73	—	3,375,200	8,340,000 [6]	(7)
1973/74	—	3,472,300	8,580,000 [6,8]	(7)
1974/75	—	3,723,000	9,200,000 [6]	(8)
1975/76	17,000 [4] (7)	4,010,600	9,910,000 [6]	(9)
1976/77	—	4,605,500	11,380,000 [6,9]	(9)

[1] 250 M.T. of Penjamo 62 and 100 M.T. of Lerma Rojo 64.

[2] Mostly Mexipak 65 (white—Siete Cerros); some Mexipak Red (Indus 66). In addition, 20 M.T. were available locally.

[3] 40,000 M.T. of Mexipak Red (Indus 66) and 2,000 M.T. of Mexipak 65 (Siete Cerros).

[4] From Mexico; 56.6 percent Yocora and 38.8 percent Nuri.

[5] Of the total area, about 81 percent was Mexipak, 12.5 percent Indus 66, 4 percent Norteno 67, and 1 percent Inia 66 (ref. 10).

[6] The distribution of this area by province was:

	Punjab	Sind	NWFP	Baluchistan	Total
			Percent		
1971/72	75	16	8	1	100
1972/73	74.8	15.6	9.1	0.5	100
1973/74	76.4	16.2	8.7	0.5	100
1974/75	73.8	16.6	9.1	0.6	100
1975/76	74.4	14.1	10.8	0.7	100
1976/77	74.6	15.6	9.1	0.7	100

[7] Mexipak continued to be the dominant variety. Newer varieties being grown extensively included Pakistan 20, Chenab 70, Barani 70, SA–42, Khushal 60, and Khushal 69 (ref. 11).

[8] Three improved varieties developed at Lyallpur were released to growers in the fall of 1973; Sandal, Lyallpur–73, and Pari. A new variety, Potohar, was released in 1974 for barani growing conditions.

[9] Two new varieties were released: Punjab 76, a cross of Nianari–60 CB 151 (Mexican) x S–948 (Pakistan); and LU-26, a Blue Silver (Sonalika) x Khushal 69 cross. Punjab 76 is expected to replace Chenab 70. Punjab 76 was developed at Punjab Agriculture Institute; LU–26 at the College of Agriculture at Lyallpur. (ref. 12.)

References

(1) *Rice and Wheat in Pakistan*, Spring Review (AID), March 17, 1969, pp. 3–5.
(2) *1966—67 CIMMYT Report*, pp. 64–65; Cannon, *op. cit.*, p. 90.
(3) "Country Field Submission: Pakistan, FY 1971," AID, August 1969, Appendix A, table 1.
(4) Foreign Agricultural Service Report PK–0003 from Rawalpindi, January 20, 1970, p. 4.
(5) Foreign Agricultural Service Telegram TOFAS 02 from Islamabad, January 5, 1972.
(6) Data provided by S. M. A. Jafri, Statistical Officer, Planning Unit, Ministry of Agriculture and Works, Agriculture Wing, Islamabad, December 5, 1973.
(7) Letter from Alvin E. Gilbert, Agricultural Attaché, American Embassy, Islamabad, October 2, 1975. The 1972/73 and 1973/74 data were obtained from the Planning Unit of the Ministry of Agriculture.
(8) Foreign Agricultural Service Report PK–7014 from Islamabad, May 20, 1977, p. 1.
(9) Foreign Agricultural Service Telegram TOFAS 48 from Islamabad, April 12, 1978.
(10) *1969–70 CIMMYT Report*, p. 90.
(11) *CIMMYT Annual Report, 1972*, p. 50.
(12) Foreign Agricultural Service Reports from Islamabad: PK–70006, February 17, 1977, p. 1; PK–7014, May 20, 1977, p. 2; PK–7024, August 29, 1977; letter from Gilbert, January 17, 1978.

China (People's Republic)

The Mexican wheats are well known to the People's Republic of China (PRC). It is thought that the first experimental quantities of seed were introduced from Pakistan sometime in 1968 or 1969.[1] Several years of small-scale testing followed in the early 1970's, utilizing seed obtained from Australia as well as Pakistan.[2] In 1973, the PRC Embassy in Mexico sent two staff members to CIMMYT to discuss research work and collect publications.[3]

During the early 1970's, the PRC imported the following quantities of Mexican wheat seed: 1972, 2 M.T.; 1973, 5,034 M.T.; and 1974, 14,701 M.T.[4] The most recent shipments, those intended for planting in the fall of 1974 and the spring of 1975, were broken down as follows (in percent): Potam, 61.6; Tanori, 24.7; Saric, 7.0; Inia, 3.5; and Jori, 3.5.[5] These seeds were purchased mainly for (1) the southern provinces, where they were planted in the fall, and (2) the northeastern provinces, where they were planted in the spring.[6] In the subtropical areas of the south, wheat has been increasingly sown after the late rice crop is harvested in the fall; more than 6,000 ha. (15,000 acres) were reportedly planted to Mexican wheats in Kwangtung Province in 1973.[7]

Several difficulties emerged:

> The most serious problem in the south was sprouting of the grain in the field when rains occurred under high temperatures before harvest. The Chinese also found Mexico-derived wheats to be susceptible to several diseases such as stripe rust, scab, and helminthosporium, which are present in China but not prevalent in Mexico.[8]

To remedy these defects, the Chinese began crossing their spring or winter wheats with Mexican spring wheats. New varieties from these crosses were released beginning in 1973.[9] Two of these included winter varieties named Peking 11 and Peking 15 released around 1975.[10]

By the time of a visit of a CIMMYT team in May 1977, Mexico-derived varieties or Mexican-Chinese crosses were growing in every provincial research academy and commune visited. Tanori 71 seemed to be the best adapted Mexican variety. The group, which did not travel south of Nanking, understood that:

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[1] Letter from R. Glenn Anderson, Associate Director, Wheat Program, CIMMYT, January 10, 1978.

[2] *Plant Studies in the People's Republic of China*, A Trip Report of the American Plant Studies Delegation, National Academy of Sciences, Washington, 1975, p. 56.

[3] Letter from Haldore Hanson, Director-General, CIMMYT, January 17, 1974.

[4] Letters from Richard A. Smith, Agricultural Attaché, American Embassy, Mexico City, January 18, 1974 (data from the Director-General of Statistics, Secretariat of Industry and Commerce), August 29, 1975.

[5] *Plant Studies . . ., op. cit.*, p. 56. The total quantity referred to in this report was 15,750 M.T.

[6] "Statement of Haldore Hanson, Director-General of CIMMYT, to International Centers Week, September 13, 1977," p. 6.

[7] "PRC Sows Mexican Wheat Varieties," *Foreign Agriculture* (USDA), October 20, 1975, p. 13.

[8] Hanson, *op. cit.*, September 1977, pp. 6, 7.

[9] *Ibid.*, p. 7.

[10] Benedict Stavis, "Agricultural Research and Extension Services in China," *World Development*, May 1978, pp. 638, 643 (fn. 34).

—In the region south and southwest of the Yangtze River, *most* of the wheat area of 5 million hectares is planted with Chinese-Mexican crosses; and

—In the three northeast provinces, north of the Great Wall, another 2 million hectares are planted mainly with Chinese-Mexican crosses or with varieties introduced from Mexico.[11]

The expansion of the HYV's into the south was previously noted by a visiting delegation of U.S. plant scientists (including Dr. Borlaug) in the fall of 1974:

> The introduction of the early maturing, high-yielding Mexican wheat varieties . . . has permitted expansion of fall-sown spring wheats into areas in the south where little or no wheat was formerly planted. Most of the anticipated expansion will be in the southern part of the conventional winter wheat belt, and in areas farther south, such as Hupei, Hunan, Kiangsi, Chekiang, Kwangsi, and Kwantung. There are other local areas further north where the Mexican type of spring wheat may be used successfully.[12]

In September 1977, the Director-General of CIMMYT noted: "By rough estimate, Mexican germ plasm now appears in the pedigree of 1/4 of the Chinese wheat crop."[13] Since the wheat area totaled about 27.9 million hectares in 1977, this estimate, if correct, would suggest a total HYV area of about 7 million hectares (17.3 million acres).

Early maturity is a requisite of all wheat varieties raised in China, and it is a major goal to grow most of the wheat under irrigated conditions. Therefore, the development of semi-dwarf varieties is receiving considerable attention.[14] Some work has been done on hybrid varieties, but is still limited to the research stage.[15]

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[11] Hanson, *op. cit.*, September 1977, p. 7.

[12] *Plant Studies . . ., op. cit.* Also noted by G.F. Sprague in "Agriculture in China," *Science*, May 9, 1975, p. 553.

[13] Hanson, *op. cit.*, September 1977, p. 7.

[14] V.A. Johnson and H.L. Beemer, Jr. (eds.), *Wheat in the People's Republic of China*, National Academy of Sciences, CSCPRC Report No. 6, 1977, pp. 27, 31, 33. (This is a trip report of the American wheat studies delegation, May/June 1976. Curiously, the report provides very little information on the use of Mexican varieties.)

[15] *Ibid.*, p. 34; notes compiled by Haldore Hanson during a briefing by Fang Tsui-nung, Deputy Secretary of the Chinese Academy of Agricultural Sciences, Peking, May 28, 1977.

NEAR EAST

The Near East is defined in this report as West Asia and North Africa. It is a rather diverse region geographically. In West Asia, HYV wheat is raised largely under irrigation (often partial or limited) or fairly high rainfall. It is grown under irrigation in Egypt. But in the remainder of North Africa and Turkey, HYV wheat usually is raised under rainfed conditions. Winter wheat and durum wheat also are grown in some of the countries.

Throughout the region, there is a relative scarcity of statistics on the HYV area. Particularly severe data shortages exist for recent years for Algeria, Morocco, Iraq, and Turkey. In some cases, the only data are for government distribution of HYV seed. Where the HYV data do exist, they sometimes do not adequately differentiate between varieties (the statistics for Afghanistan, for instance, include all improved varieties).

The statistical situation has improved in some small ways since the last report was issued for the years through 1974/75 and deteriorated in other important ways. The improvements are the inclusion of data for two countries for which recent information was previously not available: Lebanon and Turkey (the Turkish estimates, however, are unofficial and only for 1976/77). And some information will be reported below for several countries which were only briefly mentioned in footnotes, if at all, in previous editions. On the other hand, estimates for 2 years (1973/74 and 1974/75) in two countries, Iran and Morocco, have been judged inadequate and dropped. Also, no recent official data have been found for Algeria, Iraq, and Morocco. As a result of these gaps, the Near East is being dropped from the time series data previously summarized in Chapter V, "Summary of Estimated Area Data."

The tables which follow summarize what statistical information has been found for 11 countries. Even more limited information for four other countries is briefly noted below. Seed supply is a problem throughout the region.

Cyprus.—Mexican varieties have been extensively used on Cyprus. As of the 1973 period, about 14,000 ha. (35,000 acres) reportedly were planted to Mexican-type varieties, principally Pitic 62.[1] As of 1977, all the bread wheat varieties, which occupy about 20,000 ha. (49,400 acres), were of Mexican origin; the principal varieties were Pitic 62, Hazera 2152, and Hazera 18. About 90 percent of the durum wheat area of about 10,000 ha. (24,700 acres) was planted to HYV's: principally Capeiti 8 (Capelli x Eiti), with Aronas (a sister line of Cocorit 71) undergoing multiplication.[2]

Jordan.—The wheat statistics in Jordan do not differentiate between improved local and Mexican varieties. Cocorit, Juri 69, and Stork appear promising and are undergoing seed multiplication. The total area of improved

[1] Letter from Abdul Hafiz, Project Manager, Regional Field Food Crops Project, FAO, Cairo, December 6, 1973.

[2] Letters from A. Hadjichristodoulou, Agricultural Research Officer, Agricultural Research Institute, Ministry of Agriculture and Natural Resources, Nicosia, December 1, 1977, January 10, 1978, and February 4, 1978. Details on the two durum varieties are provided in Technical Bulletins 10 (Capeti, January 1973, 11 pp.) and 22 (Aronas, September 1977, 14 pp.) of the Agricultural Research Institute.

and high-yielding varieties was rather small—about 7,000 ha. in 1974/75, 10,000 ha. in 1975/76, and 12,000 ha. in 1976/77.[3]

Oman.—Semi-dwarf wheat varieties were first imported from Pakistan and India in 1970. Mexipak was found suitable for some areas and in 1973 seed was distributed to farmers on a limited scale. During 1977/78, 40 M.T. of Kalysona was imported from India and distributed. Two other Indian varieties were "awaiting release" in early 1978: Safed Lerma and HD 1999.[4]

Yemen (Arab Republic).—Only limited wheat research has been done in Yemen (AR). An FAO wheat breeder has been stationed in Taiz for a relatively short period of time. Sonalika and Kalyansona have been grown under flood irrigation. It is believed that some more appropriate varieties can be developed with local crossing.[5]

Yemen (People's Democratic Republic).—About 40 percent of the relatively small wheat area in Yemen is planted to HYV's.[6]

Israel is not considered a developing nation and is covered in a footnote below.[7]

Several regional wheat improvement programs have been conducted. The first was an FAO/UNDP project on wheat and barley established in 1962, which has grown into a larger program on field food crops.[8] The second was the Arid Lands Agricultural Development Program (ALAD) sponsored by the Ford Foundation, which did some wheat research and testing in Lebanon. The ALAD work recently has been absorbed by the newly established International Center for Agricultural Research in the Dry Areas (ICARDA). ICARDA has durum wheat as one of its major crops.

Dwarf wheats were first introduced to the Near East in 1963. In that year, a former student of Borlaug grew the new Mexican varieties at a station north of Cairo. Egyptian use of the varieties, however, was very limited until the early 1970's.[9]

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[3] Letters from John Hyslop, Food and Agriculture Officer, USAID, Aman, February 22, 1976, December 13, 1977; conversation with J. P. Stivastava, ICARDA, Aleppo, May 8, 1978.

[4] Mahmood Akhtar, "Varietal Position of Wheat in Oman," Directorate of Agriculture, Muscat; forwarded by A. Solaiman, Director General of Agriculture, Sultanate of Oman, Muscat, January 31, 1978.

[5] Conversation with Srivastava, *op. cit.;* letter from John J. Young, Agricultural Development Officer, USAID, Sana'a, February 1, 1978.

[6] Letter from J.S. Bakshi, Agronomy Expert, UNDP/FAO Improvement of Crop Production, Aden, May 6, 1978.

[7] Israel has made use of improved varieties at every stage of their development. Local strains were replaced by Florence x Aurore (Appendix B) after World War II, and this variety was widely grown until the late 1960's. It was replaced partly by the original Mexican varieties and the dwarf varieties in the middle to late 1960's. Next, varieties were selected out of CIMMYT material. Finally, the CIMMYT material was crossed with local varieties. The latter two categories have accounted for nearly all the wheat area since the early 1970's. The principal varieties in 1977, accounting for about 90 percent of the area, were Ceeon (Sion/Hazera 2152), Lakhish, and Miriam. Four new varieties, one a durum, are under development. (Yoav Kislev and Michael Hoffman, "Research and Productivity in Wheat in Israel," *The Journal of Development Studies,* January 1978, pp. 166–181; letters from Moshe J. Pinthus. Dept. of Field and Vegetable Crops, Hebrew University, Rehovot, June 15, 1975, November 6 and 25, 1977.)

[8] "Regional Research Corporation in the Near East; UNDP-FAO Regional Project on Improvement and Production of Food Field Crops in the Near East and North Africa," (Project REM 71/293) FAO, Rome, 1975, 28 pp.

[9] Lennard Bickel, *Facing Starvation; Norman Borlaug and the Fight Against Hunger,* Readers Digest Press, 1974, pp. 246, 247, 249.

Table 10—Afghanistan: HYV Wheat

Crop year	Quantity of seed imported	Area planted or harvested[7]		
	Metric tons	*Hectares*	*Acres*	
1965/66	50 [1] (1)	—	—	
1966/67	420 [2] (2)(3)	1,800	4,500	(7)
1967/68	—	22,000	54,400	(8)
1968/69	—	122,000	301,500	(8)
1969/70	—	146,000	360,800	(9)
1970/71	—	232,000	573,200	(10)
1971/72	6,000 [3] (4)	255,000	630,000	(10)
1972/73	2,000 [4] (5)	450,000	1,112,000	(10)
1973/74	500 [5] (5)	475,000	1,173,700	(5)
1974/75	—	522,000	1,289,900	(5)
1975/76	10 [6] (6)	522,000	1,289,900 [8]	(11)
1976/77	—	770,000	1,902,700 [9]	(11)

[1] Lerma Rojo 64A. Imported from Mexico in 1965.
[2] Lerma Rojo 64: 250 M.T. from Mexico (ref. 2), and 170 M.T. from Pakistan (ref. 3).
[3] Mexipak from Pakistan; 2,000 M.T. certified, 4,000 M.T. uncertified. As of December 1971, the certified seed had been received and planted; the uncertified seed was received in time for spring planting (some lots, however, were reported to have low germination and to be weevily). These imports were stimulated by a prolonged drought.
[4] Bezostaya.
[5] Kavkaz (Kafqaz, Qavkaz); a Russian variety (Lutescens 314 H147 x Bezostaja 1).
[6] From India, CY 1975.
[7] Total improved varieties, including both spring and winter wheats.
[8] Leading varieties included Mexipak, Bakhtar (Baktar), Bezostaya, and Kavkaz. Bakhtar = E_1-314, a selection from the International Disease Nursery.
[9] Mexipak and Bakhtar were the leading spring varieties; Chenab also was grown. Kavkaz was the leading winter variety, followed by Bezostaya.

References

(1) "The Green Revolution," *Participant Report*, USAID, Kabul, summer 1969, p. 2.
(2) *Fourth Annual Wheat Seminar, August 28, 1969—September 8, 1969*, Ministry of Agriculture and Irrigation, Kabul; summary paper by Joe Motheral.
(3) *CIMMYT Report, 1967—68*, pp. 59, 72.
(4) Letters from John R. Wilson, Food and Agriculture Officer, USAID, Kabul: November 27, 1971; November 17, 1973.
(5) Letter from Ernest J. Barbour, Chief, Public Administration—Rural Development, USAID, Kabul, September 28, 1975.
(6) Letter from Robert C. Tetro, Assistant Agricultural Attaché, American Embassy, New Delhi, February 6, 1978.
(7) *Agricultural Development in Afghanistan, with Special Emphasis on Wheat*, U.S. Agricultural Review Team, July 1967, pp. 31–32.
(8) Department of State Airgram TOAID A–574 from Kabul, December 8, 1969, p. 8 (table III).
(9) Letter from Joe R. Motheral, Food and Agriculture Officer, USAID, Kabul, September 23, 1970.
(10) Letters from Wilson, *op. cit.*, October 24, 1973, November 17, 1973.
(11) Letters from Raymond E. Fort, Chief, Agriculture Division, USAID, Kabul, November 28, 1977, April 15, 1978.

Table 11—Algeria: HYV Wheat

Crop year	Quantity of seed imported	Area planted or harvested	
	Metric tons	*Hectares*	*Acres*
1969/70	1,500 [1] (1)	5,100	12,600 (4)
1970/71	17,200 [2] (2)	140,000	346,000 [4] (2)
1971/72	—	320,000	790,700 [5] (4)
1972/73	15,468 [3] (3)	600,000	1,482,600 [6,7] (5)(6)
1973/74	—	NA	NA
1974/75	—	(670,400)	(1,656,400) [8]
1975/76	—	NA	NA [9]
1976/77	—	(300,000)	(741,300) [9]
1977/78	3,800 [10] (11)		

[1] Principally from Mexico. Substantial quantities of seed also were imported from Morocco and Tunisia.

[2] In 1970, Mexico exported 11,182 M.T. of seed to Algeria; the business was handled by a Swiss firm, however, and the exports are listed as going to Switzerland in the official Mexican statistics (ref. 7).

[3] Reported export of seed from Mexico to Algeria in 1972.

[4] Seed supplies were sufficient for 48,000 ha. (365,700 acres), but some arrived late. About 138,000 ha. (341,000 acres) were planted to Mexican varieties (Inia 66, Siete Cerros, and Tobari) and 2,000 ha. (4,940 acres) to Italian varieties.

[5] Inia 66, Siete Cerros, Tobari, and Strampelli.

[6] Principally used in the socialist sector.

[7] About 80 percent bread wheats and 20 percent durums. Within the bread category, the varietal breakdown was: Siete Cerros 70 percent, Inia 25 percent, and Tobari 5 percent. The durum variety was Jori C69. Strampelli performed as well as Siete Cerros, but was still under seed multiplication.

[8] Rough estimate derived from CIMMYT statement that during the 1974/75 season, more than 60 percent of the bread wheat area and 15 percent of the durum area were under HYV's and that during the 1971–74 period, about 39 percent of the total area was planted to bread wheat and 61 percent to durum wheat (ref. 8). These proportions were applied to an FAS estimate of 2.05 million ha. of wheat in 1974/75. Siete Cerros continued to be the leading bread variety and Cocorit was the leading durum variety (ref. 9).

[9] Rough estimate derived in part from information provided by ref. 10. Almost entirely bread wheat. Information from another source (ref. 11) suggests that the HYV area declined substantially in 1975/76 and 1976/77 due to drought and a shortage of seed. Siete Cerros continued to be the predominant HYV bread wheat variety, representing about 90 percent of the HYV area, followed by Strampelli with 8 percent, and other (Anza, Tobari, and Inia) 2 percent. HYV durum wheats, planted in limited areas, include Cocorit, Inrat 69, Capeti, and Montpellier; Jori did not prove adaptable.

[10] Siete Cerros. From Mexico and Spain.

References

(1) Conversation with Dr. Gregorio Martinez of CIMMYT, December 17, 1970.
(2) *CIMMYT Annual Report, 1970/71,* p. 51.
(3) Letter from Richard A. Smith, Agricultural Attaché, American Embassy, Mexico City, January 18, 1974 (data from Director General of Statistics, Secretariat of Industry and Commerce).
(4) *CIMMYT Annual Report, 1972,* p. 70.
(5) Zhor Zerari, "Cereal Production Set Back by Bad Weather" (in French), *Algerie-Actualite,* Algiers, July 1973, p. 8.
(6) Letter from W. L. McCuistion, Project Cereales-CIMMYT, Algiers, January 28, 1974.
(7) Letter from John D. Jacobs, Assistant Agricultural Attaché, American Embassy, Mexico City, February 12, 1974.
(8) *CIMMYT Report on Wheat Improvement, 1975,* pp. 107, 112.
(9) Letter from R. Glenn Anderson, CIMMYT, February 10, 1976.
(10) Materials provided by J.P. Srivastava, ICARDA, Aleppo, March 29, 1978.
(11) Letter from George Varughese, IDGC-CIMMYT, Algiers, March 6, 1978.

Table 12—Egypt: HYV Wheat

Crop year	Quantity of seed imported	Area planted or harvested		
	Metric tons	*Hectares*	*Acres*	
1970/71	—	150	400 [1,2]	(1)
1971/72	—	1,800	4,500 [1,2]	(1)
1972/73	—	20,100	49,700 [1]	(1)
1973/74	—	212,800	525,900 [1]	(2)
1974/75	—	78,600	194,300 [3]	(2)
1975/76	—	74,300	183,500 [4]	(2)
1976/77	—	125,500	310,100 [5]	(2)

[1] Principally Mexipak (Siete Cerros); some Super-X. Chenab-70 appears to have been released in 1972/73.
[2] Seed multipled on Ministry of Agriculture farms in 1969/70 and released to agrarian reform farms in 1970/71 and other farmers in 1971/72 (ref. 3).
[3] Reasons for this drop included: (a) Government policies which required forced delivery of three ardebs for every feddan planted instead of the two required for traditional varieties, and (b) shattering, grain color, and baking and milling qualities (refs. 1, 4, and 5). The latter problems were expected to be countered through increased use of Chenab-70 (ref. 4).
[4] About 20,000 ha. were planted to Chenab 70, which was expected to increase during the 1976/77 season (ref. 4).
[5] This increase in HYV area occurred despite discontinuation of the support price for Mexipak; as a result, the price of Mexipak dropped below that of local varieties (for reasons discussed in fn. 3 above) (ref. 6).

References

(1) Letter from R. Gerald Saylor, The Ford Foundation, Cairo, October 29, 1975 (data from the Institute of Agricultural Economics, Ministry of Agriculture).
(2) Foreign Agricultural Service Telegram TOFAS 50 from Cairo, March 3, 1978.
(3) H. A. El-Tobgy, *Contemporary Egyptian Agriculture*, The Ford Foundation, Beirut, January 1974, p. 96.
(4) Letter from Gordon W. McLean, the Ford Foundation, Cairo, March 22, 1976.
(5) John Waterbury, "Aish: Egypt's Growing Food Crisis," American Universities Field Staff, Fieldstaff Reports, Northeast Africa Series, Vol. 19, No. 3, December 1974, p. 5; Richard Critchfield, "Egypt Plunges Into Green Revolution," *Christian Science Monitor*, January 20, 1975.
(6) Letter from James B. Fitch, Project Specialist, Agricultural Economics, The Ford Foundation, Cairo, March 4, 1978.

Table 13—Iran: HYV Wheat

Crop year	Quantity of seed imported	Area planted or harvested [3]	
	Metric tons	*Hectares*	*Acres*
1968/69	1,500 [1] (1)	10,000	25,000 [4] (3)
1969/70	4,000 [2] (2)	37,000	91,400 [4] (3)
1970/71	—	63,000	155,700 [4] (3)
1971/72	—	125,000	308,900 [4] (3)
1972/73	—	138,000	341,000 [4,5] (3)
1973/74	—	NA	NA
1974/75	—	NA	NA
1975/76	—	140,000	346,000 [4,6] (4)
1976/77	—	NA	NA

[1] Penjamo 62 imported from Turkey.

[2] About 2,500 M.T. of Bezostaya No. 1 from USSR and 1,500 M.T. of Mexican Inia 66 from Denmark. Of the Bezostaya seed, 500 M.T. were planted during the 1969/70 season and 2,000 M.T. during the 1970/71 season (ref. 5).

[3] Area under Wheat Impact Program.

[4] Mexican varieties. In addition, the following area was planted to other varieties:

	Bezostaya	Improved local	Total
		Hectares	
1968/69	—	25,000	25,000
1969/70	5,000	NA	5,000
1970/71	15,000	22,000	37,000
1971/72	38,000	120,000 [a]	158,000
1972/73	34,000	126,000 [a]	160,000
1975:76	NA	225,000 [b]	NA

a Principally Roshan and Omid.

b Composed of: Omid 120,000 ha.; Roshan 80,000 ha.; and other 25,000 ha. The other category is composed of Adl, Arvandi, Bayott, Khazar 1, and Moghan 1. Arvandi, Khazar, and Moghan include Mexican varieties in their parentage and could be considered HYV's (see fn. 5 below).

[5] In 1972/73, five new varieties, several with Mexican parentage, were released: Karaj 1, Karaj 2, Arvani 1, Khazar 1, and Moghan 1. About 200 M.T. of Moghan were available for distribution. (Ref. 6.)

[6] Inia, Penjamo I.

References

(1) Foreign Agricultural Service Reports from Tehran: IR–9003, January 20, 1969; IR–9006, February 5, 1969.

(2) Foreign Agricultural Service Report IR–0018 from Tehran, October 8, 1970.

(3) H. Kaveh, "Iran," *Proceedings of the Fourth FAO/Rockefeller Foundation Wheat Seminar* (Tehran, May/June 1973), FAO, Rome, 1974 (AFP: FC/21), p. 72. Similar data are reported in Addvar Aresvik, *The Agricultural Development of Iran*, Praeger, 1976, p. 137 (table 7.2).

(4) Letters from Paul Ferree, Agricultural Attaché, American Embassy, Tehran, December 20, 1977, and February 15, 1978 (data from the Extension Service).

(5) Letter from Dale K. Vining, Agricultural Attaché, American Embassy, Tehran, December 29, 1973.

(6) *CIMMYT Report on Wheat Improvement, 1973*, p. 78.

Table 14—Iraq: HYV Wheat

Crop year	Quantity of seed imported	Area planted or harvested		
	Metric tons	*Hectares*	*Acres*	
1965/66	5 [1] (1)	—	—	
1966/67	—	—	—	
1967/68	800 [2] (2)	6,400	15,800 [1]	(1)(4)
1968/69	—	41,700	103,000 [1]	(1)
1969/70	—	195,200	482,400 [1]	(1)
1970/71	—	125,000	309,000 [1]	(4)
1971/72	70,000 [3] (3)	950,000	2,347,500 [4,5]	(3)
1972/73	—	595,000	1,470,200 [4,6]	(5)
1973/74	—	700,000	1,729,700	(5)
1974/75	—	750,000	1,853,300 [7]	(5)
1975/76	—	NA	NA	
1976/77	—	NA	NA	
1977/78	—	NA	NA[8]	

[1] Mexipak.
[2] Mexipak shipped from West Pakistan, September 1968.
[3] Mexican varieties imported in response to a drought-induced crop failure in 1970/71. According to Mexican sources, 61,000 M.T. of seed wheat were shipped to Iran in 1971 (the business was handled by a Swiss firm and the exports are listed as going to Switzerland in the official Mexican statistics) (ref. 6). Of the 60,000-ton total, about 25,000 tons were Mexipak (Siete Cerros), 20,000 tons Inia, and 15,000 tons Jori (ref. 7). In addition, 10,000 tons of Inia were imported from Algeria (ref. 7). In total, this is the largest seed import recorded in this publication.
[4] Includes Mexipak, Jori 69c (irrigated areas), and Inia 66 (rainfed areas).
[5] This is an enormous increase in HYV area over 1970/71—almost too large to believe. Yet it is possible, considering the massive quantity of seed imported and assuming a seeding rate of about 75 kg./ha.
[6] There was a sharp drop in overall wheat area from 1971/72 to 1972/73.
[7] Principally Mexipak, followed by Inia and Jori.
[8] A new variety of Mexican origin is under multiplication: Abu-Ghraib 3 (7C x On) x (Inia x Buck Man). It is more resistant to disease than Mexipak. (Ref. 8.)

References

(1) Abdul Hafiz, "Report on Cereal Improvement and Production in Iraq," FAO, Cairo, April 1971, p. 7.
(2) Foreign Agricultural Service Aircomm from Rawalpindi to Program Compliance Division, Export Marketing Service, November 20, 1969.
(3) Letters from Abdul Hafiz, Project Manager, Regional Project, Field Food Crops, FAO, Cairo, December 6, 1973, and January 28, 1974.
(4) Abdul Hafiz, "Impact, Problems, and Potential of the Green Revolution," *Cereal Improvement and Production*, Information Bulletin, Near East Project, FAO, Jan./Apr., and May/Aug., 1973, p. 19.
(5) Data provided by N. Erus, Chief, Basic Data Unit, Statistics Division, FAO, Rome, January 19, 1976.
(6) Letter from John D. Jacobs, Assistant Agricultural Attaché, American Embassy, Mexico City, February 12, 1974.
(7) Letter from Hafiz, *op. cit.*, March 25, 1974.
(8) Letter from Omar Ali Ameen, Head, Cereal and Legume Crops, Directorate General for Field Crops, Abu Ghraib Farm, Badhdad, December 21, 1977.

Table 15—Lebanon: HYV Wheat

Crop year	Quantity of seed imported	Area planted or harvested		
	Metric tons	*Hectares*	*Acres*	
1967/68	—	50	120	(1)
1968/69	—	400	1,000 [1]	(2)
1969/70	—	2,500	6,200 [1]	(2)
1970/71	—	7,000	17,300	(2)
1971/72	—	12,000	29,700	(2)
1972/73	—	20,000	49,400	(2)
1973/74	—	20,000	49,400	(3)
1974/75	—	17,000	42,000	(3)
1975/76	—	20,000	49,400	(3)
1976/77	—	25,000	61,800 [2]	(3)

[1] Mexipak.
[2] Principally Mexipak. Juri, a durum, is planted on 3,000 to 4,000 ha. (7,400 to 9,900 acres). Three new varieties have been developed and are undergoing multiplication in 1978.

References

(1) Abdul Hafiz, "Impact, Problems and Potential of the Green Revolution," *Information Bulletin*, Cereal Improvement and Production, Near East Project, FAO, Jan./April and May/Aug., 1973, p. 19.
(2) Estimate provided by Dr. Kingma of the Arid Lands Regional Agricultural Program, Ford Foundation, Beirut; forwarded in letter from Shackford Pitcher, Agricultural Attaché, American Embassy, Beirut, November 21, 1973.
(3) Letter from Pitcher, January 9, 1978 (estimates provided by Lebanese Cereals and Sugar Beets Office).

Table 16—Morocco: HYV Wheat

Crop year	Quantity of seed imported	Area planted or harvested	
	Metric tons	*Hectares*	*Acres*
1967/68	1 [1] (1)	200	500 (2)
1968/69	500 [2] (3)(4)	4,900	12,100 [3] (5)
1969/70	—	46,500	114,900 [4,5] (5)
1970/71	—	90,000	222,400 [4,5] (5)
1971/72	—	206,000	509,000 [4,5] (5)
1972/73	—	294,000	726,500 [4,5] (5)
1973/74	—	NA	NA [6]
1974/75	—	NA	NA [6,7]
1975/76	—	NA	NA [6]
1976/77	—	NA	NA [6]

[1] Siete Cerros (plus 150 kg. of Super X).
[2] Included 250 M.T. of Siete Cerros, 100 of Inia 66, 100 of Tobari 66, 25 of Penjamo 62, and 25 of Norteno.
[3] 50 percent, Siete Cerros; rest, Inia 66, Tobari 66, and Penjamo 62 (ref. 6).
[4] Unofficial estimate made by U.S. Agricultural Attaché based on quantities of certified seed available, discussions with USAID agriculturists, and other information.
[5] The estimated breakdown by variety was as follows:

	908 (Italian)	Siete Cerros	Tobari	Other	Total
		Percent			
1969/70	44	32	25	0	100
1970/71	95	3	2	0	100
1971/72	91	7	—	2	100
1972/73	95	5	0	0	100

[6] Certified wheat seed production and distribution was as follows (refs. 7 and 8):

	Production	Distribution
	Metric tons	
1973/74	37,016	44,645
1974/75	27,036	27,068
1975/76	44,316	13,398
1976/77	30,720	20,617
1977/78	51,100	41,900

One rule of thumb would be to multiply the quantity of seed by a factor of 10 to get a rough estimate of the areas farmers could have planted. The problem is that the seed data show a rather large degree of variation both within and between production and distribution, especially for 1975/76. Moreover, another account suggests that 25,000 M.T. of Nasma seeds were distributed in 1975/76, considerably more than the distribution indicated above (ref. 8). The probable reasons for these differences are too complex to summarize here (ref. 9). In any case, the figures do not include uncertified seed traded among farmers.
[7] The varietal breakdown of certified seed production in 1974/75 was: Nasma, 40 percent; 908, 33 percent; Siete Cerros, 20 percent; 2306, 7 percent (ref. 10). Nasma 149 was developed by the Direction de la Recherche Agronomique (DRA) in Rabat from a cross of Dwarf Breadwheat 69 (from Montpellier, France) and Florence Aurore (ref. 9).

References

(1) Department of State Airgram A–272 from Rabat, December 26, 1967.
(2) *CIMMYT Report, 1967–68*, p. 73.
(3) *Morocco: Wheat*, Spring Review (AID), March 13, 1969, pp. 2, 4.
(4) "Moroccan Agriculture Thrives on High-Yield Mexican Wheat," *Front Lines* (AID), February 15, 1969, p. 3.
(5) Foreign Agricultural Service Telegrams TOFAS 10 and TOFAS 13 from Rabat, March 22 and 27, 1974.
(6) *CIMMYT Report, 1968–69*, pp. 57, 97.
(7) Letter from Jerome M. Kuhl, Agricultural Attaché, American Embassy, Rabat, December 29, 1977.
(8) Foreign Agricultural Service Reports from Rabat: MO–6030, November 29, 1976; MO–8012, April 3, 1978; and MO–8018, May 16, 1978.
(9) Letter from Kuhl, March 21, 1978.
(10) Letter from Arthur Dommen, Visiting Agricultural Economist, USAID, Rabat, October 2, 1975.

Table 17—Saudi Arabia: HYV Wheat

Crop year	Quantity of seed imported		Area planted or harvested		
	Metric tons		*Hectares*	*Acres*	
1969/70	2 [1]	(1)(2)	—	—	
1970/71	0.8 [2]	(2)	—	—	
1971/72	—		—	—	
1972/73	—		140	350 [3,4]	(3)
1973/74	—		2,000	5,000 [3]	(2)
1974/75	680 [3,5]	(4)	10,000	24,700 [3]	(4)(5)
1975/76	500	(6)	12,000	29,700 [6]	(7)
1976/77	1,150	(6)	13,500	33,400 [7]	(6)

[1] Gift from West Pakistan; principally Mexipak 65 (known locally as White Mexipak).
[2] Super X; provided by the Ford Foundation in 1970.
[3] Super X (Mexipak).
[4] Planted on seed multiplication and demonstration farms. A national wheat improvement program was begun in 1971 utilizing the Super X seed provided by the Ford Foundation in 1970.
[5] Imported from Egypt. Of this amount, 500 M.T. were distributed for the 1974/75 crop and the remaining 180 M.T. were used for the 1975/76 crop.
[6] Two additional varieties were released: Jori 69, a durum variety; and Arz, a bread wheat (ref. 4).
[7] Area planted with certified seed from the Ministry of Agriculture and Water. Total area planted to HYV seed is estimated to be about three times this figure.

References

(1) Foreign Agricultural Service Aircomm from Rawalpindi to Program Compliance Division, Export Marketing Service, November 20, 1969.
(2) Letters from Keith E. Henderson, Development Assistance Corporation, Riyadh, November 15, 1975, December 6, 1975.
(3) M. El-Saadi, "Saudi Arabia" *Proceedings of the Fourth FAO/Rockefeller Foundation Wheat Seminar* (Tehran, May/June 1973), FAO, Rome, 1974 (AGP:FC/21), p. 101.
(4) Keith Henderson, "Status of High Yielding Wheat Varieties in Saudi Arabia," Development Assistance Corporation, Riyadh, September 1975.
(5) *Wheat Production in Saudi Arabia*, Ministry of Agriculture and Water, Riyadh, January 1975, pp. 6–8.
(6) Letter from M.Z. Jowana, Director, Crop Production Research Division, Ministry of Agriculture and Water, Riyadh, January 30, 1978.
(7) Estimates provided by Keith Henderson to John Parker, ERS, USDA, Riyadh, January 14, 1976.

Table 18—Syria: HYV Wheat

Crop year	Quantity of seed imported		Area planted or harvested		
	Metric tons		*Hectares*	*Acres*	
1970/71	5,160 [1]	(1)	38,000	94,000 [3]	(3)
1971/72	—		75,000	185,300 [3]	(4)
1972/73	50 [2]	(2)	121,000	299,000 [3,4]	(2)
1973/74	—		224,000	553,500 [3]	(2)
1974/75	—		269,000	664,700 [3]	(2)
1975/76	—		340,800	842,000 [3]	(5)
1976/77	—		362,800	896,600 [3]	(6)

[1] The varietal composition was as follows: Siete Cerros, 1,870 M.T.; Inia, 1,150; Pitic 62,770; Lerma Rojo, 740; Mexipak 65, 540; and Penjamo 62, 90. Origin not indicated.

[2] Jori S–69.

[3] The distribution of HYV area between irrigated and rainfed land was as follows:

	Irrigated	Rainfed	Total
		Percent	
1970/71	66	34	100
1971/72	33	67	100
1972/73	44	56	100
1973/74	42	58	100
1974/75	44	56	100
1975/76	47	53	100
1976/77	39	61	100

[4] Mainly Pitic 62 and Siete Cerros.

References

(1) Abdul Hafiz, "Report on Cereal Improvement and Production in Syria," FAO, Cairo, July 1971, p. 6.

(2) Foreign Agricultural Service Telegram TOFAS 34 from Damascus, April 6, 1976. (Data provided by the Syrian Ministry of Agriculture and Agrarian Reform.)

(3) Abdul Hafiz, "Present Status of Wheat Research and Production Programmes in the Near East Region," FAO, Cairo, September 1971. Table III.

(4) Estimate provided by Dr. Kingma of the Arid Lands Regional Agricultural Program, Ford Foundation, Beirut; forwarded in Foreign Agricultural Service Telegram TOFAS 22, April, 23, 1974.

(5) Letter from Shakford Pitcher, Agricultural Attaché, American Embassy, Damascus, February 14, 1978 (data provided by Mohammad Deeb, Director of Statistics and Planning, Ministry of Agriculture and Agrarian Reform).

(6) Letter from the Department of Economy, Foreign Ministry, to Shackford Pitcher, May 9, 1978.

Table 19—Tunisia: HYV Wheat

Crop year	Quantity of seed imported	Area planted or harvested		
	Metric tons	*Hectares*	*Acres*	
1967/68	50 (1)	800	2,000	(2)
1968/69	—	12,000	29,700	(3)
1969/70	—	53,000	131,000	(3)
1970/71	—	102,000	252,000	(3)
1971/72	—	60,000	148,300 [1]	(3)
1972/73	—	149,200	368,700 [2]	(3)
1973/74	—	155,000	383,000 [2]	(4)
1974/75	—	225,700	557,700 [2]	(5)
1975/76	—	205,700	508,300 [2,3]	(6)
1976/77	—	228,400	564,400 [2,3]	(6)

[1] The decrease may have been due to dissatisfaction of farmers with the quality of seed distributed during the 1970/71 season (ref. 7).

[2] Composed of both HYV bread and durum wheats. The proportion of each was as follows:

	Bread	Durum	Total
		Percent	
1972/73	66.4	33.6	100
1973/74	35.5	64.5	100
1974/75	24.3	75.7	100
1975/76	17.6	82.4	100
1976/77	19.6	80.4	100

The most important durum variety is INRAT 69, a semi-dwarf developed in Tunisia from a cross of two local varieties (Kyperounda x Mahmoudi) (ref. 5). Newer varieties in the testing stage carry the Norin 10 dwarfing gene (ref. 8).

[3] The crop reporting program was converted to a more scientific system starting with the 1976 crop (a probability area sample).

References

(1) "Tunisia to Close Wheat Gap," *Front Lines* (AID), December 15, 1968, p. 7.

(2) Foreign Agricultural Service Report TN–9004 from Rabat, June 26, 1969.

(3) Letter from Gaylord L. Walker, Senior Agriculture Sector Advisor, USAID, Tunis, October 19, 1973 (data provided by the Office of Cereals).

(4) Foreign Agricultural Service Report TN–4004 from Rabat, December 17, 1974 (data provided by the Ministry of Agriculture Planning Office).

(5) Letter from Carl E. Ferguson, Agricultural Development Officer, USAID, Tunis, November 25, 1975 (preliminary estimates by the Office of Cereals).

(6) Letter from Ferguson, February 1, 1978.

(7) Letter from Buford H. Grigsby, Project Officer, Agricultural Production and Research, USAID, Tunis, November 8, 1973.

(8) Letter from George Varughese, CIMMYT, c/o Ford Foundation, Tunis, February 8, 1974.

Table 20—Turkey: HYV Wheat

Crop year	Quantity of seed imported	Area planted or harvested		
	Metric tons	*Hectares*	*Acres*	
1966/67	60 [1] (1)	600	1,500	(1)
1967/68	22,100 [2] (2)	170,000	420,000	(2)
1968/69	—	579,000	1,430,700 [3,4]	(3)
1969/70	—	623,000	1,539,400 [3,4]	(3)
1970/71	—	640,000	1,581,400 [3,4,5]	(3)
1971/72	—	650,000	1,606,200 [3,6]	(3)
1972/73	—	NA	NA	
1973/74	—	NA	NA	
1974/75	—	NA	NA [7]	
1975/76	—	NA	NA [7]	
1976/77	—	(2,200,000)	(5,436,200) [7,8]	(4)
1977/78	—	NA	NA [7]	

[1] Sonora 64.
[2] Only 17,000 M.T. planted in fall; remainder planted in spring 1968. Included: 6,190 M.T. of Lerma Rojo 64; 6,950 of Penjamo 62; and 5,860 of Super X.
[3] Estimates of the area planted to Mexican HYV's by another source (ref. 5) differ somewhat:

	Hectares	*Acres*
1968/69	650,000	1,606,200
1969/70	650,000	1,606,200
1970/71	509,000	1,257,700
1971/72	623,000	1,539,400

[4] In addition, the following areas were planted to two other improved varieties, principally Bezostaya and some Wanser, in the winter wheat areas (ref. 6) (also see ref. 5):

	Hectares	*Acres*
1968/69	7,280	18,000
1969/70	69,200	171,000
1970/71	287,700	710,000

100 M.T. of Bezostaya, a Russian variety, were imported in the fall of 1967. Wanser is an American variety which was first imported in 1967.
[5] The HYV's in the spring wheat area were composed of both Mexican and Italian types. The varietal composition of the Mexican varieties was: Penjamo 89 percent, Lerma Rojo 9 percent, Super X 1 percent, and Pitic 1 percent (ref. 7).
[6] A comprehensive survey of 1,250 wheat farms in six regions of Turkey in the spring of 1973 suggested that the area of HYV's was as follows in 1971/72 (ref. 7):

	Hectares	*Acres*
Mexican	1,090,000	2,693,400
Italian	85,200	210,500
Bezostaya	758,500	1,874,300
Total	1,993,700	4,778,200

The Mexican figure is considerably larger than the one reported above for 1971/72; similarly, the Bezostaya figure is considerably larger than the one reported in fn. 4 above for 1970/71.
[7] According to the quantity of officially supplied seed made available, the following areas could have been planted to HYV's (including Mexican, Italian, and Russian varieties):

	Hectares	*Acres*
1974/75	401,600	992,300
1975/76	493,000	1,218,200
1976/77	780,900	1,929,500
1977/78	740,000	1,828,500

These figures, however, do not include the area planted with seed traded among farmers. Thus, the total area would be expected to be considerably larger, though by an unknown amount. (Ref. 8.)
[8] Figure based on estimate, prepared by Charles K. Mann and associates at the Wheat Research and Training Center in Ankara, that about 26 percent of the total wheat area was planted to a rather wide range of HYV's in 1976/77. Varieties included in this category were:
Winter wheat
Bread. Bezostaya, Bolal, Kirac 66, Wanser, Libellula, Etiole de Choisy.
Spring wheat
Bread. Penjamo 62, Mara, Compodoro, Cumhuriyet 75, Sakarya 75, Inerio, Conte Marzotto, Orse.
Durum. Gediz, Dicle 74.

The 26 percent proportion was multiplied by a USDA estimate of total area of 8.6 million hectares in 1976/77 (official Turkish figures have usually been higher) to produce an area estimate of 2.236 million ha., which was rounded down to 2.2 million. This figure is 2.8 times as large as the 1976/77 figure reported in fn. 7 above. Much of the difference, as suggested in fn. 7, could be accounted for by farmer-supplied seed. If the same proportion of the HYV area was planted to Mexican and Italian varieties as in 1971/72 (fn. 6 above), the area of these two types of varieties would have been 1.3 million ha. (3.2 million acres).

References

(1) *1966–67 CIMMYT Report*, p. 69; *CIMMYT Report, 1967–68*, p. 59; Joseph R. Willlams, "Wheat Program Leads Off Turkey's New 5-Year Plan," *Foreign Agriculture*, November 20, 1967, p. 5.

(2) *Wheat in Turkey*, Spring Review (Airgram TOAID A–141 from Ankara, March 21, 1969), pp. 5–6, 12–13. (Also see L. M. Humphrey, *Mexican Wheat Comes to Turkey*, USAID Ankara, April 1969.)

(3) Letter from William L. Davis, Agricultural Attaché, American Embassy, Ankara, November 16, 1973.

(4) Estimates prepared by Charles K. Mann and associates of the Wheat Research and Training Center, Ankara, forwarded by Walter A. Stern, Agricultural Attaché, American Embassy, Ankara, February 1, 1978. (Based on field trips and surveys.)

(5) Oddvar Aresvik, *The Agricultural Development of Turkey*, Praeger, 1975, pp. 168, 179–180. (Based on esimates provided by the Wheat Reserach and Training Project.)

(6) Abdul Hafiz: "Report on Cereal Improvement and Production in Turkey," FAO, Cairo, July 1971, p. 10; "Present Status of Wheat Research and Production Programmes in the Near East Region," FAO, Cairo, September 1971, Table III.

(7) Letter and enclosure from Keith M. Byergo, Deputy Food and Agriculture Officer, USAID, Ankara, October 12, 1971.

(8) Estimates prepared by the Office of the Agricultural Attaché, American Embassy, Ankara (based on reports of officially supplied seed); forwarded by Stern.

AFRICA

Wheat is fairly important in the more temperate nations of Africa (aside from the Mediterranean countries, which are included with the Near East). The HYV's have found a modest foothold in several of these countries. Coverage in this section basically will be limited to six: Ethiopia, Kenya, Nigeria, Rhodesia, Sudan, and Tanzania. South Africa is discussed briefly in a footnote below.[1]

In addition, the HYV's are being grown in several other African nations. In Senegal, HYV's were planted for the first time in 1973/74, on an experimental basis.[2] Small areas also are reported to Chad, West Cameroon, Ghana, Mali, and Upper Volta.[3]

Ethiopia[4]

Ethiopia began to utilize improved and semi-dwarf wheat varieties on a commercial level in 1968. The area of these varieties reportedly expanded as follows (in hectares): 1968, 950; 1969, 4,500; 1970, 15,000; 1971, 40,000; and 1972, 45,000.[5] Their use in Arusi Province, a principal wheat-growing area, rose from 14 percent of the area in 1969 to about 75 percent in 1973.[6] Many of the varieties were developed in Kenya. Ethiopia also imported some wheat seed from India in the early 1970's: 0.87 M.T. in 1970/71 and 11.0 M.T. in 1970/71 (Kalayansona and Sonalika).[7]

As of the 1975/76 to 1977/78 period, wheat was raised on about 500,000 ha. in Ethiopia. Of this, about 30 percent or 150,000 ha. (perhaps 160,000 ha. in 1977/78) was bread wheat, and 70 percent or 350,000 ha. was durum wheat. Most of the bread wheat area appears to have been sown to improved varieties and some semi-dwarfs, but the durum area is made up almost entirely of traditional varieties. Hence, the total improved and semi-dwarf area probably was about 150,000 ha. (371,000 acres) in 1976/77. Most of the improved varieties have Mexican blood in them, but the proportion of the area actually planted to semi-dwarfs probably is rather low.

[1] The Republic of South Africa has made extensive use of Mexican varieties. During 1976/77, about 865,700 ha. (2.14 million acres) were planted to varieties of Mexican extraction. This represented nearly 46 percent of the total wheat area. The leading Mexican varieties were: Inia 66, T4, Zambesi, SST3, Bella, and Tobari 66. (Based on letter and table provided by Aubrey D. Venter, Counsellor, Embassy of South Africa, Washington, D.C., January 5, 1978. Also, letter from R. Glenn Anderson, CIMMYT, January 17, 1978.) The parentage of four of the five leading Mexican varieties, as well as others, is provided in the *CIMMYT Review, 1975*, p. 96; the two leading varieties not listed are: Zambesi (Siete Cerros x Lee x ND74); and SST3 (Inia 66 x Cal.).)

[2] Letter from Victor Lateef, Regional Agriculture Officer, USAID/ADO, Dakar, September 25, 1975.

[3] Letter from R. Glenn Anderson, CIMMYT, September 19, 1975.

[4] Aside from the first paragraph, this section is based on (a) materials provided by Felix F. Pinto, an FAO technician who worked on wheat breeding in Ethiopia for 6 years (forwarded by Kenneth H. Sherper, Chief, Rural Development Office, USAID, Addis Ababa, February 14, 1978), and (b) a letter from Mr. Pinto (now with FAO in Kenya), March 20, 1978.

[5] Alemayehu Wodageneh, "Ethiopia," *Proceedings of the Fourth FAO/Rockefeller Foundation Wheat Seminar* (Tehran, May/June 1973), FAO, Rome, 1974, p. 65.

[6] *CIMMYT Report on Wheat Improvement, 1973*, p. 71.

[7] Data provided by Robert C. Tetro, Jr., Assistant Agricultural Attaché, American Embassy, New Delhi, November 28, 1975. These varieties performed well under irrigation in the Auas Valley, but production was discontinued after 1974.

The main bread wheat areas were in the Arusi and Bale Provinces. In 1976, the Arusi Agricultural Development Unit (ARDU) multiplied and distributed about 1,000 M.T. of five improved varieties of seeds: Kanga, Mamba, Enkoy (K 4500), Romany B.C., and Dereselegn. Three varieties were no longer recommended because of susceptibility to rust (Laketch, Supremo, and Kt-Fn-My 48), but continued to be grown due to lack of alternative seed supplies. Varieties added to the recommended list after 1976—none of which is semi-dwarf—include: K–6290–Bulk (related to K. Nyati), K–6106–8 (sib. of K. Kiboko), CE 14393 (from Ecuador), and Son 64 x Ske-Ane-CC (Chilean-Mexican variety).[8]

Through 1975, no high-yielding durum varieties had been identified for general release. In 1976, three varieties were released for limited use in the Debre Zeit area: Gerardo VZ, Cisne'S, and Cocorit 71. Durum research is to be coordinated from the Agricultural Experiment Station at the University at Debre Zeit.

There is considerable potential for increasing wheat production in Ethiopia. One major constraint is the lack of any nationwide organization to produce and distribute improved seed.

Kenya

Wheat improvement has an unusually long history in Kenya. In 1910, a prominent wheat grower, Lord Delamere, employed an English plant breeder, G. W. Evans, to develop varieties resistant to stem rust. Evans initially employed varieties from Italy (Rieti), Australia, Canada (Red Fife), and Egypt. In 1920, a full-time plant breeder, G. I. L. Burton, was employed by the government. Originally, Burton was stationed near Nairobi, but in 1928 the main station was set up at Njoro.[9] Some of the varieties developed by Burton at Njoro, such as Kenya, Kenya Blanco, and Kenya Rojo, were used in the early Mexican work. Unfortunately, the parentage of most of these varieties is unknown; Burton's records were lost in a fire.[10]

Over time, Mexican varieties were used in the Kenyan breeding program. In 1975, CIMMYT listed seven varieties of at least partial Mexican extraction (see Table 1 for names and parentage).[11] Since then, 10 other varieties have been released and commercially grown which have Mexican stock in their parentage. The total area of the 17 varieties was about 261,000 ha. (646,000 acres) in 1977.

Five of these varieties were released in the Kenya series in 1975 and 1976 and have Tobari as a parent: K. Paka, K. Tembo, K. Nungu, K. Kifaru, and K. Fahari.[12] The first four, plus K. Mbweha, are semi-dwarfs. They were planted

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[8] The latter two varieties were given limited release for the higher altitudes only, because of slight susceptibility to stem rust.

[9] Foreign Agricultural Service Report No. 46 from Nairobi, October 16, 1959. Similar information, with slightly different dates, is provided in *Growing Wheat in Kenya*, Plant Breeding Station, Njoro (?), 1974, p. 1 (the date of Evans' employment is placed in 1906 and the establishment of the station at Njoro in 1927).

[10] E. C. Stakman, *et al.*, *Campaigns Against Hunger*, Belknap/Harvard University Press, Cambridge, 1967, pp. 84–85; Lennard Bickel, *Facing Starvation: Norman Borlaug and the Fight Against Hunger*, Readers Digest Press, 1974, p. 132. Kentana resulted from a Kenya x Mentana cross.

[11] *CIMMYT Review, 1975*, pp. 95–96.

[12] G. Kigma, "Wheat Research and Production in Kenya in 1976," CIMMYT, Nakuru, December 1977, p. 4; other information provided by Dr. Kigma, January 21, 1978. These varieties also include CI 8154–Fr^2, a Mexican variety obtained from Colombia in 1961, in their ancestry.

on about 23,300 ha. (57,500 acres) in 1977, about 17 percent of the total wheat area.[13]

Nigeria

Commercial bread wheat production in Nigeria began with development of four irrigation schemes in the northernmost part of the country in 1959. The area under wheat increased from a few hundred acres in 1959/60 to about 2,000 ha. (5,000 acres) in 1967/68. In 1960, over 300 varieties were introduced for selection purposes.[14]

Trials of Mexican semi-dwarf varieties began in 1966/67. By 1974/75, the HYV wheat area had expanded to 3,200 to 4,900 ha. (8,000 to 12,000 acres).[15] The area was divided between Kano State and the area around Lake Chad. Wheat is raised during the dry season under irrigation.

The principal early HYV's were Indus 66 and Siete Cerros. Sonora 63 was released in 1971, and Inia 66 is likely to be recommended in the future. With good management, yields of 4 M.T. per hectare are considered commercially feasible. Wheat is expected to have a prominent place in the cropping system. USAID has sponsored the assignment of a wheat production specialist and the training of a number of Nigerians at CIMMYT.[16]

Rhodesia

Rhodesia is making extensive use of HYV's. CIMMYT estimated that about 22,000 ha. (54,400 acres) were planted to two HYV's (Zambesi and Tokwe) in 1973.[17] More recently, most of the wheat area has been planted to a dwarf known as Limpopo (Son 64//T2Pr/NA 160/3/Tokwe): the proportions were placed at 80 percent of the area in 1976 and 70 percent in 1977. Some of the remaining areas also were planted to dwarfs, including Tokwe.[18]

Precise HYV area estimates are not available for recent years (the Rhodesian government does not reveal official area estimates). However, a recent USDA report suggests a total wheat area of about 28,000 ha. in 1976.[19] The 1977 area was reported about 20 percent smaller,[20] which would suggest roughly 22,400 ha. If these figures are reasonably accurate, the area of Limpopo alone would

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[13] Letters from Roger W. Gray, Manager, Kenya Seed Co., Ltd., Nakuru, January 3, 1978, and February 11, 1978. The 1977 data are based on the "1st Field Estimates of the 1977 Planted Wheat Crop," Kenya Wheat Board, November 1977.

[14] D. J. Andrews, "Wheat Cultivation and Research in Nigeria," *Nigerian Agricultural Journal*, Vol. 5, No. 2, pp. 67–72.

[15] The former estimate was provided for 1975 in Foreign Agricultural Service Report No. NA–6093 from Lagos, February 6, 1975, p. 5; the latter estimate was provided for 1974/75 in a letter from R. Reddin, Agricultural Research Institute, Ahmadu Bello University, to G. Anderson, CIMMYT, December 24, 1975 (forwarded by Winton Fuglie, USAID, Lagos).

[16] Reddin, *op. cit.*; Winton L. Fuglie, "Wheat in Nigeria," USAID, Lagos, January 30, 1976, 10 pp.

[17] *CIMMYT Review, 1975*, p. 96.

[18] Based on materials provided by Coerie Badenhorst, Cereal Breeder, Crop Breeding Institute, Ministry of Agriculture, Causeway, to R. Glenn Anderson, CIMMYT, December 28, 1977.

[19] "Reference Tables on Area-Yield-Production of All Grains," USDA, Foreign Agriculture Circular FG 19–77, December 20, 1977, p. 6.

[20] Badenhorst, *op. cit.*

have been roughly 22,400 ha. (55,400 acres) in 1976 and approximately 15,700 ha. (38,800 acres) in 1977. The area planted to other HYV's would have raised the HYV total further.

A new HYV, Gwebi (a selection of Yecora 70), outyielded Limpopo in 1977 and is expected to become more widely grown in 1978. The Mexican variety Torim 73 also has proved promising and is expected to be released early in 1978.[21]

Sudan[22]

Improved wheat, principally from Egypt (such as Giza 155), has been used extensively in the irrigated wheat area in the Sudan for a number of years. In 1971, a semi-dwarf variety known as Mexicani was released. It is a selection from a Mexican cross (table 1).[23] The estimated area planted to Mexicani has increased significantly:

Crop year	HYV area	
	Hectares	*Acres*
1972/73[24]	2,400	6,000
1973/74	20,000	49,400
1974/75	50,000	123,600
1975/76	126,000	311,300
1976/77	150,500	371,900
1977/78	(147,600)	(364,700)

As of 1975/76, the Mexicani area represented about 36 percent of the total wheat area; the rest was planted to Giza 155. Mexicani has a number of advantages over Giza 155—such as earlier maturity, stronger stem, and a 20 percent yield advantage—but it also has a yellow grain which is less attractive to farmers. Still, its area is expected to expand.

During the 1976/77 season, the HYV area represented about 50 percent of the total wheat area. The proportion increased to about 60 percent in 1977/78. The overall wheat area declined somewhat during the period because of some temporary problems related to irrigation and cultural practices.

[21] *Ibid.*

[22] Based, except as noted, on letters from Dr. M. A. Khalifa, Plant Breeding Section, Gezira Research Station, Agricultural Research Corporation, Wad Medani, Sudan, January 12, 1976, February 13, 1978.

[23] Selections from the same cross have been released as Moghan 1 in Iran, Anza in California, and WW15 in Australia (C. O. Qualset, *et al.*, "Anza, New High-Yielding, Short-Statured Wheat Variety," *California Agriculture*, February 1973, pp. 14–15).

[24] M. A. Khalifa, "Sudan," *Proceedings of the Fourth FAO/Rockefeller Foundation Wheat Seminar* (Tehran, May/June 1973), FAO, Rome, 1974, p. 106.

Tanzania

Mexican wheat varieties have been under study and in use in Tanzania for several years. In 1973, the Lyamungu Research Station made 270 M.T. of seed with Mexican parentage available, of which 180 M.T. were W–3503 and 90 M.T. were W–3654.[25] Most of the varieties developed at the Njoro Station in Kenya are reselected at Lyamungu. In 1975, it was estimated that nearly all the varieties used in Tanzania carried Mexican germ plasm; the semi-dwarf proportion, however, was not known.[26] In 1977, improved varieties represented about 80 percent of the total area (which was estimated by FAS/USDA at about 50,000 ha.).[27] Recommended varieties for 1978 included a Mexican semi-dwarf, Kororo (YSOE–8156 R x Kal.). Other recommended varieties included: T. Trophy, T. Nyati, T. Mbuni (Trophy x K 6106–1), T. Tai, T. Kosi (K 6648–6 or K. Fahari), T. Joli (K 6793–6 or Trophy x K 6106–16 A), T. Kwecha, and T. Mamba.[28]

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[25] Letter from Henry C. Wiggin, USAID, Dar es Sallam, November 15, 1973. Canada has been assisting wheat development at the Lyamungu Institute since 1970.

[26] Letter from W.E.P. Davis, Agronomist, Agronomic Research Project (Ministry of Agriculture), Lyamungu, Moshi, October 21, 1975.

[27] Letter from Thomas J. Worrick, Agricultural Economist, USAID, Dar es Salaam, February 9, 1978.

[28] Letter from Jerry Kingma, CIMMYT, Nakuru, Kenya, February 14, 1978.

LATIN AMERICA

Although the HYV's discussed in this report were developed in Mexico, their principal use—aside from Mexico itself—until recently has been in Asia and the Near East. This has been because the varieties most nearly achieve their yield potential under assured water supplies and with the application of fertilizer. Wheat is seldom raised under these conditions in Latin America outside of Mexico.

Not all of the Mexican varieties have been of semi-dwarf stature. Research programs, utilizing the predwarf varieties, were initiated in several Latin American countries by the Rockefeller Foundation in the 1950's.[1] A number of improved varieties of traditional height were developed, many of which are of significant economic importance.

The introduction of the semi-dwarf varieties in these national breeding programs is of more recent vintage—stemming largely from the mid-1960's. Some semi-dwarf varieties have been introduced and many others are being studied.[2] Substantial areas of semi-dwarf and short HYV's recently have been planted in Argentina and Brazil.

Such information as we have on the development and use of both improved and semi-dwarf varieties in 10 countries (Argentina, Brazil, Chile, Colombia, Ecuador, Guatemala, Mexico, Paraguay, Peru, and Uruguay) is summarized in this section.

Based on developments to date, it would appear that the area planted to HYV's could increase substantially in Latin America in the future, particularly as irrigation and the use of fertilizer expand.

Argentina

Improved varieties of wheat reportedly have been available to Argentine farmers since 1935. As of the mid-to-late 1960's, almost the entire wheat area was planted with *improved* varieties.[3]

In 1963, CIMMYT's predecessor organization (the Office of Special Studies) began a program of informal cooperation with the Coordinated National Wheat Breeding Program of the Instituto Nacional de Technologia Agropecuaria (INTA). In 1972, the first two *semi-dwarf* varieties (reselections) were named and approved for release: Marcos Juarez and Precoz Paranaá.[4] INTA subsequently has released other new varieties including Balcarceno, Diamante, Calden, Insurgentes, and Leones.

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[1] Details on early programs are provided in E. C. Stakman *et al.*, *Campaigns Against Hunger*, Belknap/Harvard University Press, Cambridge, 1967, pp. 216–234. This book is cited at several points in this section.

[2] Details are provided in the annual reports of CIMMYT from 1966/67 to the present.

[3] D. H. Fienup, R. H. Brannon, and F. A. Fender, *The Agricultural Development of Argentina*, Praeger, 1969, p. 106.

[4] *CIMMYT Annual Report, 1972*, p. 84. Further details on the breeding work in Argentina are provided on pp. 84–86.

Three semi-dwarf varieties also were developed by Dekalb Argentina S.A.: Lapacho (released in 1973), Tala (1973), and Urunday (1975). Their parentage is:

- Lapacho and Urunday. Pitic-Chris sib x Sonora 64;
- Tala. Sonora 64–Klein Rendidor x Massau x No. 5.

The parentage of Lapacho and Urunday is the same as Ciano 67, but the selections have more resistance to stem rust races in Argentina. Tala is slightly taller than Lapacho and Urunday and does not resemble other Mexican varieties as closely.[5]

Just how large an area is planted to the semi-dwarf varieties is most uncertain. CIMMYT has placed the 1973 area at about 50,000 ha. (123,600 acres).[6] Most of the farmers, however, save their own seed and no official estimate of the area planted to noncertified ("non fiscalizado") seed is available.

Estimates for the 1975/76 season vary widely. A CIMMYT official, following a trip to Argentina in late 1975, reported that research officials estimated 16 to 18 percent of the total area was planted to Lapacho, Urunday, and Marcos Juarez.[7] A subsequent estimate by a high Argentine agricultural official placed the HYV area at about 30 percent of the total.[8] Two wheat breeders reported estimates of 50 to 60 percent of the total area planted to the Dekalb varieties (with most in Lapacho and Tala). An additional area was planted to the INTA varieties.[9] The total wheat area during the 1975/76 season was about 8.56 million ha. (21.1 million acres).

The HYV area as of the 1976/77 season also was uncertain. Reports from the U.S. agricultural attaché initially placed the proportion at 30 to 40 percent (compared with about 20 percent in 1975/76), and subsequently at up to 30 percent.[10] Private sources again placed the HYV proportion at well over 50 percent, probably about 60 percent.[11] A CIMMYT official also cites a 60 percent figure.[12] The total wheat area during the 1976/77season was about 6.43 million ha. (15.9 million acres).

Obviously, these reports produce widely varying estimates of the total HYV area. It has not been possible to reconcile them. But at the minimum, they would produce HYV areas as follows: 1975/76 (20 percent), 1.05 million ha. (2.6 million acres); 1976/77 (30 percent), 1.93 million ha. (4.8 million acres). Upper variants would be about twice this large. Clearly, a massive area is being planted to HYV's.

Considering the very limited use of fertilizer and irrigation for wheat in Argentina, this development is somewhat surprising. But the HYV's would be expected to give a greater response than improved varieties to the high natural fertility of the Pampas. Moreover, their shorter growing season has facilitated use in double-cropping rotations with soybeans and sunflowers. They may be followed with a summer pasture crop.[13]

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[5] Letter from Dr. Charles F. Krull, Dekalb Italiana, Centro Ricerche, 31040 Chiarano (TV), Italy, January 28, 1976. Dr. Krull formerly was in charge of wheat breeding for Dekalb in Argentina.

[6] *CIMMYT Review, 1975*, p. 98.

[7] Letter from R. Glenn Anderson, CIMMYT, December 30, 1975.

[8] Cited by Norman Borlaug, CIMMYT, in phone conversation, February 17, 1976.

[9] Letters from: Krull, *op. cit.*; John W. Gibler, Technical Coordinator, Programa Acelerado de Melhoramento do Trigo, Porto Alegre, Brazil, November 4, December 4, 1975 (citing estimates from colleagues in Argentina).

[10] "Argentina's Wheat Crop and Exports Near Record Levels," *Foreign Agriculture*, December 13, 1976, p. 8; Foreign Agricultural Service Report AR–7056 from Buenos Aires, May 27, 1977.

[11] Letters from Krull, *op. cit.*, November 2, 1977, December 6, 1977. Krull notes that most of the HYV area in 1977 was west of Buenos Aires; relatively little was planted in the south and southwest.

[12] Letter from Anderson, *op.cit.*, January 10, 1978.

[13] Borlaug, *op. cit.*, February 18, 1976; "Argentina's Wheat Crop . . .," *op. cit.*

Brazil

Brazil has a long history of use of *improved* wheat. One of the earliest and best known varieties was Frontana; it was developed from a cross of Fronteria (Alfredo Chaves 6 x Polyssu) and Mentana (an Italian variety discussed in Chapter II) in 1930 and was released in 1940. It is still being grown in the western part of Rio Grande do Sul State and was used in breeding a number of the Mexican varieties. Frontana itself, however, is not a semi-dwarf.[14]

The area of *semi-dwarf* varieties has been rather limited until recently. They have been principally planted in Paraná state. In 1975, Paraguay 214, an introduction from Paraguay and a sister line of the Mexican semi-dwarf variety Jaral, was planted on more than 200,000 ha. (500,000 acres), and represented 19.3 percent of total wheat production in Paraná. Sonora 63/64 accounted for about 7.1 percent of total wheat production in Paraná in 1975.[15]

A commission from Paraná purchased 14,000 M.T. of semi-dwarf Mexican wheat (9,000 M.T. of Tanori F71 and 1,000 M.T. of Jupateco F73 from Mexico, and 4,000 M.T. of Inia F 66 from California) for use in 1976.[16] The trial proved very successful.[17] It is estimated that about 650,000 ha. (1,605,000 acres) of Mexican-type semi-dwarf varieties were planted in Paraná state in 1977. Of this amount, about 61 percent was in the western part of the state and 39 percent in the north. The principal varieties were, in decreasing order of seed sales: Tanori, Inia, Paraguay 214, Jupateco, and Paraguay 281.[18]

The other major wheat-producing state is Rio Grande do Sul. Semi-dwarfs have not been grown commercially. However, four varieties with fairly short straw and Norin 10–Brevor in their ancestry have been raised commercially: IAS–52, IAS–53, IAS–54, and IAS–55.[19] In total, they accounted for the following proportions of the wheat area in the state (in percent): 1970/71, 5.2; 1971/72, 28.0; 1972/73, 31.4; 1973/74, 54.7; and 1974/75, 43.4. Of the four, IAS–54 was by far the most important—representing 34.5 percent of the total area by 1974/75 (by which time IAS–52 and IAS–53 were no longer used).[20] During this

[14] Letters from Dr. John W. Gibler, Research Coordinator, Federacao das Cooperativas Brasileiras de Trigo (FECOTRIGO), Porto Alegre, October 14, 1975; November 4, 1976. Details on the Brazilian wheat breeding work are provided in the CIMMYT annual reports starting in 1969–70. For background, also see John C. McDonald, "An Assessment of Brazil's Efforts to Grow More Wheat," *Foreign Agriculture*, December 29, 1969, pp. 8, 9.

[15] Statistics from "Visao Panoramica da Triticultura Paranese na Safra de 1975," Paraná Agronomic Institute (IAPAR), Londrina, p. 2. (forwarded by Edmond Missiaen, Assistant Agricultural Attaché, American Embassy, Brasilia, February 27, 1976). Paraguay 214 accounted for 11.0 percent of wheat production in Paraná in 1974 and 1.5 percent in 1973. Sonora 63/64 represented 2.1 percent of production in 1974 and none in 1973.

[16] Gibler, *op. cit.*

[17] Foreign Agricultural Service Report BB–66037 from Brasilia, November 5, 1976, p. 2.

[18] Letter from John W. Gibler, Research Director, Programa de Pesquisa, OCEPAR, Londrina-Pr., Brazil, February 2, 1978. Gibler notes that Paraguay 281 is not a semi-dwarf but is an old variety he originally developed when in Colombia. It came from Paraguay, where it was selected from about the 1960 International Rust Nursery. It has the parentage 1879–Mayo 54.

[19] The genealogy of three of the varieties is:

- -IAS–52. IAS 15/3/Mayo 54/Norin 10/Brevor 28–LC.
- -IAS–53. IAS 16/3/Yaktana 54/Norin 10/Brevor 21–LC.
- -IAS–54. IAS 16/5/Norin 10/Brevor 17//Yaqui 53/3/Yaqui 50/4/Kentana 54 B.

The pedigree of IAS 55 is unknown. The average height of IAS–54 and IAS–55 is reported to be 90 cm. The varieties were developed by the Federal Research Program at Pelotas. (Based on information provided in *Lavoura Arrozeira*, August 1976, p. 23; Anton C. Zeven, *Genealogies of 14,000 Wheat Varieties*, CIMMYT, 1976, pp. 50, 51; and letter from Gibler, February 24, 1978.)

[20] *Lavoura Arrozeira, op. cit.*, p. 23 (provided by James Truran, Assistant Agricultural Attaché, American Embassy, Brasilia, January 26, 1978).

period, the total wheat area in the state averaged about 1.5 million ha.; thus the area of short varieties in 1974/75 may have been about 650,000 ha. (1.6 million acres).

Wheat is considerably less important in other states in Brazil. Semi-dwarfs are included in the varieties recommended for Sao Paulo and Mato Grosso in 1978, and substantial areas of HYV's (including some semi-dwarfs) were raised in Sao Paulo and to a lesser extent Mato Grosso in 1977. Paraguay 214 was planted on about 2,000 ha. (5,000 acres) in Mato Grosso in 1975. The seed purchasing commission from Paraná, noted earlier, also purchased 4 M.T. of 15 semi-dwarf Mexican varieties for testing in Bahia state. A sample of Siete Cerros did very well. The Sao Francisco valley is considered to have considerable potential.[21]

One factor limiting expansion of semi-dwarfs in certain areas of Brazil is a toxic action induced by high aluminum levels in acid soils. A cooperative program was established with CIMMYT in 1972 to select more resistant varieties.

Chile

A wheat improvement program was initiated in Chile in 1955 in cooperation with the Rockefeller Foundation. Dr. Joseph A. Rupert, who had worked in Mexico, started testing lines from the two countries. Several subsequently were selected and released in 1958 (Orofen and Rulofen) and 1961 (including Orofen 50 and Chifen).[22]

Wheat research carried out by the Institute de Investigaciones Agropecuarias (INIA) led to the release of 21 varieties from 1964 to 1975. Of these, 11 semi-dwarfs are raised commercially. As of 1976/77, they were to be raised on about 193,000 ha. (476,900 acres).[23].

The leading semi-dwarf varieties, their year of release, and approximate percentage of total HYV area (in 1976/77) were: Toquifen (1968), 31.1; Quilafen (durum, 1970), 31.1; Melifen (1974), 10.4; Aurifen (1973), 7.8; Mexifen (1973),7.8; Antufen (1974), 5.2; Loncofen (1973), 2.6; Naofen (1974), 1.6; and other, 2.4.[24]

High-yielding varieties have been introduced by two other groups. The National Agricultural Society (Sociedad Nacional de Agricultura, SNA) sponsors an experiment station which has introduced several varieties, including SNA-1. SNA-1 is a semi-dwarf selected from materials provided by CIMMYT.[25] The Catholic University of Chile released Marianella, a new semi-dwarf variety of Mexican origin, in 1977. It is expected to be planted on about 15,000 ha. (37,000 acres) in 1978.[26]

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[21] Letters from Gibler, *op. cit.*, October 14, 1975, February 2, 1978, and February 14, 1978.

[22] Stakman, *et al.*, *op.cit.*, pp. 232, 233, 271.

[23] Letter from Ignacio Ramirez, Head, Wheat Project, Institute de Investigaciones Agropecuarias, Santiago, May 19, 1976. Area estimate based on seed sales (Telegram TOFAS 54 from Santiago, June 1, 1976).

[24] *Ibid.*

[25] Based on materials provided by the Sociedad Nacional de Agricultura to Max F. Bowser, Agricultural Attaché, American Embassy, Santiago: "Panorama Triguera de Chile," undated, 2 pp.; letter from Raul Matte Vial, Presidente, Estacion Experimental, to Bowser, March 3, 1978. Selections from the same cross as SNA-1 have been released as Mexicani in Sudan, Moghan 1 in Iran, and Anza in California (see Sudan entry, fn. 23).

[26] Letter from Dr. Patricio C. P. Parodi, Chief, Departmento de Fitotecnia, Catholic University of Chile, to Max Bowser, Agricultural Attaché, Quito, December 14, 1977. The parentage of Marianella is Ciano/Sonora 64-Kiein Rendidor/8156.

Colombia[27]

A wheat improvement program was begun in Colombia in 1926. Mexican varieties were introduced by Dr. Juan Orguela in 1949 and by Dr. Joseph A. Rupert of the Rockefeller Foundation in 1950. The first variety of Mexican ancestry released was Menkemen 52 (Mentana 48 x Kenya), a sister of Lerma 50. This was followed by Bonza 55 (Yaqui 48 x Kentana 48) in 1955 and Narino 59 in 1959. In addition to being higher yielding than native varieties, the new varieties were resistant to yellow rust.

Semi-dwarf varieties from Mexico were introduced in 1958. But the effort to incorporate the smaller plant type characteristic did not immediately gain force. Major varieties subsequently introduced through the cooperative efforts of the Rockefeller Foundation and the Instituto Colombiano Agropecuario (ICA), were:

- 1963 Tall (1.20 m.–1.25m.): Bonza 63, Crespo 63.
  Normal (1.05 m.–1.10 m.): Miramar 63, Napo 63.
  Semi-dwarf (0.95 m.–1.05 m.): Tiba 63, Tota 63.
- 1964: Normal: Miramar 64.

ICA took over direction of the Wheat Improvement Program at the end of 1964. Three tall varieties were named in 1968: Samaca 68, Sugamuxi 68, and Zipa 68. Because of their resistance to yellow rust and other qualities, the Colombian varieties found a wide distribution in other nations.

The area planted to improved and semi-dwarf varieties, however, followed a peculiar pattern. It increased through 1968 to a peak area of about 54,600 ha. (134,900 acres), and then declined through 1973 to a low of 9,200 ha. (22,700 acres). The decline reflected a more general drop in overall wheat area; some observers believe that this drop was at least partly due to imports of U.S. wheat under the PL-480 program and unfavorable prices.[28]

ICA released two new high-yielding varieties in 1976: Icata and Engativa. Both have a relatively short growing period and are resistant to rusts and to lodging. Icata is not a semi-dwarf, but Engativa is (the parentage of Engativa is Sonora 64-A-Andes 64-A x Tiba 63). Engativa has been undergoing seed multiplication; about 50 MT. were distributed to farmers in 1977. The use of Engativa and other new varieties, however, may be restrained by the relatively limited use of irrigation and fertilization for wheat.[29]

Ecuador

A wheat improvement program was established by the Ministry of Agriculture in 1956. The Rockefeller Foundation agreed to provide the advisory services of

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[27] The first three paragraphs of this section are based on: Stakman, *et al.*, *op. cit.*, pp. 222, 223, 269–271; and Reed Hertford, Carlos Trujillo, *et al.*, "Productivity of Agricultural Research in Colombia," in *Resource Allocation and Productivity in National and International Agricultural Research* (ed. by T.M. Arndt, D.G. Dalrymple, and V.W. Ruttan), University of Minnesota Press, 1977, pp. 101–113; and comments provided by ICA in 1976.

[28] Leonard Dudley and Roger Sandilands, "The Side Effects of Foreign Aid: The Case of Public Law 480 Wheat in Columbia," *Economic Development and Cultural Change*, January 1975, pp. 325–336.

[29] Foreign Agricultural Service Reports from Bogota: CO-6041, September 9, 1976, CO-7040, August 15, 1977; letters from Alfred R. Persi, Agricultural Attaché, American Embassy, Bogota, November 23, 1977, February 10, 1978; letter from Rafael Lopez Ocampo, Lider Regional Cereales Menores, ICA, Tibaitata, Bogota, February 6, 1978.

Dr. John Gibler, leader of the wheat work in Colombia. Thus, early use was made of Colombia and Mexican varieties.[30]

While the major improved varieties in current use have some Mexican ancestry, they are *not* semi-dwarfs.[31] The area planted to the improved varieties during the 1976 season totaled about 41,400 ha. (102,300 acres). The varietal composition was: Crespo 63, 34 percent; Amazonas, 25 percent; Napo 63, 13 percent; and other, 28 percent.[32] Newer varieties in the testing stage carry the dwarfing characteristic.

Guatemala

The wheat area of Guatemala has long been planted to Mexican varieties. The first introductions were made in 1949 and 1950 in the highlands, where they were evidently well adapted. A book published in 1967 stated that "for more than a decade the entire acreage of wheat in Guatemala has been sown to Mexican-bred varieties." The Mexican varieties also were joined by the Colombian variety Nariño (of Mexican extraction), which found widespread use in the 1960's.[33] Guatemala has imported significant quantities of Mexican wheat seed in recent years: 506 M.T. in 1967, 22 in 1970, and 100 in 1971.[34]

In terms of area, CIMMYT placed the total area of three Mexican varieties—Nariño 59, Pato, and Maya 74—at about 30,000 ha. (74,000 acres) in 1973.[35] Varieties adopted in subsequent years included Gloria 74, Quetzel 75, and Renya 76. It was estimated recently that about 80 percent of the total wheat area is planted with HYV's of Mexican extraction.[36] Given a total area of about 44,000 ha. in 1977 (FAS estimate), this would produce an HYV area of about 35,000 ha. (86,500 acres).

Mexico

Although the HYV wheats originated in Mexico, relatively little statistical information has been available on their use. The area planted to *improved* varieties in Mexico went over 90 percent of the total wheat area in 1957. The *semi-dwarfs* first were introduced in 1961, and began to replace the improved varieties. Unfortunately, this process does not seem to have been recorded in

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[30] Stakman, *et al.*, *op. cit.*, pp. 229, 270.

[31] Letter from R. Glenn Anderson, CIMMYT, December 9, 1975.

[32] Letter from Joe J. Sconce, AID Affairs Officer, USAID, Quito, December 8, 1977 (data provided by INIAP). Crespo, Amazonas, and Napo were "Colombian" varieties, of partial Mexican extraction, developed by Dr. Gibler. Crespo was released simultaneously in Ecuador and Colombia. Amazonas was crossed in Colombia but released in Ecuador. (Letters from: C.M. Anderson, Agricultural Attaché, American Embassy, Quito, December 30, 1975; John W. Gibler, Programa Acelerado de Melhoramento do Trigo, Porto Alegre, Brazil, March 15, 1976.)

[33] Stakman, *et al.*, *op.cit.*, p. 268; letters from Eugenio Schiever, Antigua, Guatemala, September 16, 1975, October 10, 1975.

[34] Letter from Richard A. Smith, Agricultural Attaché, American Embassy, Mexico City, January 14, 1974.

[35] *CIMMYT Report, 1975*, p. 97.

[36] Letter from Carl D. Koone, Rural Development Officer, USAID, Guatemala City, February 22, 1978 (enclosing letter from P. A. Salvador Cruz P., Coordinator Programa de Trigo, to Astolfo Fumagalli C., Subgerente General, ICTA, February 15, 1978).

statistical terms after 1964.[37] By the end of the decade, however, it was thought generally that 90 to 95 percent of the total wheat area was planted to HYV's.

Estimates of the area planted to HYV wheat from 1971 to 1976 were provided recently by the Institute Nacional de Investigaciones Agricolas:[38]

	Hectares	*Acres*
1971	683,000	1,687,700
1972	687,000	1,697,600
1973	647,100	1,599,000
1974	655,200	1,619,000
1975	700,000	1,729,700
1976	785,000	1,939,700

Only one other estimate for this period has been noted: CIMMYT suggested that the total area planted to eight varieties in 1973 was 609,000 ha. (1.5 million acres), about 6 percent less than the above estimate; inclusion of additional varieties may have raised the total.[39] New varieties introduced in 1975 for use in 1976 included Cocoraque F75, Mexicali C75, Salamanca S75, and Anahuac F75.[40]

Paraguay[41]

A National Wheat Improvement program was initiated in Paraguay in 1966. Initially, use was made of tall Mexican and other varieties. Starting in 1970, these varieties were replaced rapidly by a semi-dwarf variety known as 214/60 or Paraguay 214 (it was entry No. 214 of the 1960 International Spring Wheat Rust Nursery). Paraguay 214 is related to Kentana 54 x Norin 10-Brevor and is considered a sister of Jaral. It was planted on more than 30,000 ha. (74,000 acres), or over 60 percent of the total wheat area in 1972, but proved susceptible to diseases and was replaced by other varieties. Other Mexican semi-dwarfs planted from 1972 to 1975 included Sonora 64 and Penjamo 62; they also were phased out because of rust susceptibility. Total wheat area dropped sharply during this period. One of the three main varieties planted in 1977 is a semi-dwarf: Itapua 5 (Sonora 64 x Klein Rendidor). (Itapua 5 is a sister of Marcos Juarez INTA of Argentina and Soltane of Tunisia.)

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[37] Estimates for five groups of varieties were compiled through 1964 by Nicolas Ardito Barletta, "Costs and Social Benefits of Agricultural Research in Mexico," University of Chicago, Department of Economics, Ph.D. dissertation, 1970, pp. 136, 140. Data for the semi-dwarf group were reported for 1963 and 1964 only.

[38] Letter from Eduardo Alvarez Luna, Director General, Instituto Nacional de Investigaciones Agricolas, Mexico City, January 6, 1978.

[39] *CIMMYT Review, 1975,* p. 97. The varietal breakdown was:

	Percent
Lerma Rojo 64 and Delicias	10.3
Siete Cerros 66	12.2
Yecora 70, Cajeme 71, Tanori 71	73.9
Jori 69, Corocit 71 (durum)	3.6

[40] Luna, *op. cit.*

[41] Based on letters from: David L. Peacock, Rural Development Officer, USAID, Asuncion, November 15, 1977 (based on information provided by the National Agronomic Institute); and R. Glenn Anderson, CIMMYT, January 8, 1978.

Peru

Peru made early use of Mexican and Colombian varieties. Sierra 1 and Sierra 2 were sister lines of the Mexican variety Yaktana 54. The Colombian varieties Bonza and Narino also were utilized.[42]

In 1974, the area planted to *improved* varieties totaled about 16,300 ha. (40,300 acres). The varietal breakdown was (in percent): Ollanta, 62.1; Cahuide, 16.2; Helvia Fron, 10.9; and Tinajones, 10.8.[43] A broader definition of modern varieties would have raised the area even more.[44] None of the varieties in use through the mid-1970's, however, were semi-dwarfs.

The first Peruvian *semi-dwarf* of Mexican extraction is Participacion. The cross first was made at the Agricultural Experiment Station in La Molina in 1966. The parents were La Molina 60 (Peruvian) and Dwarf 2 (Colombian). Dwarf 2 comes from YT 54–Nor 10B and KT 54 AM–11–8113.[45] Participacion was released for commercial use in 1975. The area planted has grown as follows: 1975, 23 ha. (60 acres); 1976, 100 ha. (250 acres), and 1977, 400 ha. (1,000 acres).[46]

Uruguay[47]

A semi-dwarf variety, Estanzuela Dolores, was approved by the wheat certification committee in 1973 and commercially distributed in 1976. It was developed in Argentina and has the parentage Son 64 x SKE-LR 64 A. Unfortunately, it quickly proved susceptible to rust and was withdrawn from certification in December 1976. During the 1976/77 crop year, Estanzuela Dolores represented 3 percent of the certified seed used.

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[42] Stakman, *et al., op. cit.*, pp. 270, 271.

[43] Letter from Julio A. Castilla, Agricultural Economist, Office of Agricultural Attaché, American Embassy, Lima, Peru, November 3, 1975.

[44] See R. Villaneuva Novoa and G. Sanden Ledesma, *Trigo Huanca, Origen y Cultivo*, Ministerio de Alimentacion, Boletin No. 10, Octobre 1977, p. 5.

[45] R. Villaneuva Novoa, "Inheritance of Height and Other Characters Under Conditions of the Coast of Peru," *Proceedings of the 4th International Wheat Genetics Symposium*, Missouri Agricultural Experiment Station, Colombia, 1973, p. 612. (The parentage code for Dwarf 2 has been abbreviated.)

[46] Letter from Richard L. Barnes, Agricultural Attaché, American Embassy, Lima, December 20, 1977 (data provided by Ing. Villaneuva).

[47] Letters from Antonio M. Saravia, Director General, Centro de Investigaciones Agricolas, Montevideo, to: Mauro Fratocchi, Rural Development Office, USAID, Montevideo, January 15, 1976; Charles Breitenbach, Rural Development Officer, USAID, Montevideo, February 21, 1978.

IV. HIGH-YIELDING RICE VARIETIES

This chapter summarizes data on area of high-yielding varieties of rice planted or harvested, and fragmentary information on seed imports, for developing nations in Asia (South and East), the Near East (West Asia, North Africa), Africa, and Latin America.

Each of the continents is handled somewhat differently. Separate tables are provided for most of the Asian nations. Information for some Asian nations, and most of the nations in the other regions, is summarized in brief notes. In the case of Latin America, the notes contain available statistics in tabular form.

The tables provide annual data on major seed imports and the HYV area planted or harvested. Further details are presented in footnotes.[1] A reference is provided for each statistic cited. Data which are particularly tentative or are preliminary estimates for 1977/78 are placed in parentheses. Statistics generally are rounded to the nearest hundred; consequently, the hectare and acre figures do not convert precisely.

The parentage of most of the varieties mentioned in this chapter is summarized in table 3 in Chapter II. Further details are provided in *Parentage of IRRI Crosses, Vol. I, IR1–IR10,000,* IRRI, January 1978 (Vol. 2 also is to be published in 1978).

Most of the high-yielding varieties are semi-dwarfs (80 to 120 cm.), but some are intermediate in height (120 to 140 cm.), and a few are tall (over 140 cm.). Examples of intermediate varieties include: IR–5, BR-4 (Bangladesh), Mashuri (India), RD7 and RD9 (Thailand), and Pelita I (Indonesia). The tall varieties include RD5 (Thailand).

[1] Virtually all of the data on early imports of Philippine seed cited in this chapter were provided by Dr. Randolph Barker of IRRI. Most of these statistics were supplied through correspondence in October 1970; the reference to this data in the country tables reads simply "Barker (October 1970)." In addition, reference is made to an article by Dr. Barker, "Economic Aspects of High-Yielding Varieties of Rice, With Special Reference to National Price Policies," in the *Monthly Bulletin of Agricultural Economics and Statistics*, June 1969, pp. 1–2; it is noted as "Barker (June 1969)."

ASIA

Rice production is of immense importance in South and East Asia. It is in this region that the semi-dwarf HYV's have found their greatest application.

This section: (1) summarizes statistical data on seed imports and plantings in 11 non-Communist nations in Asia, and (2) reviews the development of improved and high-yielding varieties of rice in 3 Communist nations. The statistical tables are similar in format to those in the wheat chapter; the latter section is narrative and statistical in nature.

Several Asian countries have been excluded or omitted. Japan is a developed nation and is therefore excluded. Taiwan has long made extensive use of improved varieties and is omitted, except for brief footnote coverage below.[2]

[2] As noted in Chapter II, ponlai (japonica type) rice varieties were introduced in the 1920's and by 1940 were planted on half of the land. The proportion increased to 72 percent in 1967 and 85 percent (665,000 ha.) in 1976. The leading ponlai variety is Tainan 5 (Kachsiung 18 x Chianan 8). It was released in 1965 and increased steadily in importance, representing 53 percent of the total area or 420,000 ha. in 1975. A 1974 report of the Joint Commission on Rural Reconstruction (JCRR) noted that Tainan 5 has several agronomic weaknesses, "such as culm (over 100 cm.) which may cause a severe lodging under heavy fertilization." The JCRR was sponsoring a series of efforts "to develop a new genetic complement capable of overcoming these deficiencies." The first semi-dwarf indica was Taichung Native 1; it was released in 1960 and by 1965 accounted for about 10 percent of the total area; it then gradually decreased due to pest problems. (*29th General Report of the Joint Commission on Rural Reconstruction*, January to June 1974, Taipei, p. 14; letter from T.T. Chang, IRRI, February 23, 1976; *Taiwan Agricultural Yearbook, 1977 Edition*, June 1977, pp. 62, 68; Yi-Chung Ho, *et al.*, "Taiwan," in *Constraints to High Yields on Asian Rice Farms*, IRRI, October 1977, p. 180. ; Foreign Agricultural Service Telegram TOFAS 17 from Taipei, March 20, 1978.)

Table 21—Bangladesh: HYV Rice

Crop year	Quantity of seed imported		Area planted or harvested		
	Metric tons		*Hectares*	*Acres*	
1966/67	10		200	500	(2)
1967/68	1,500 [1]	(1)(2)	67,200	166,000	(6)
1968/69	—		154,200	381,000 [7]	(6)
1969/70	4.4		263,900	652,000 [7]	(7)
1970/71	1,800 [2]	(3)	460,100	1,137,000 [7]	(7)
1971/72	701 [3]	(4)	623,600	1,541,000 [7]	(7)
1972/73	7,000 [4]	(5)	1,064,400	2,630,000 [7]	(7)
1973/74	5,200 [5]	(5)	1,548,800	3,827,000	(8)
1974/75	—		1,443,600	3,567,000 [7,8]	(8)
1975/76	1,100 [6]	(4)	1,552,000	3,835,000 [8,9]	(9)
1976/77	—		1,329,800	3,286,000 [8]	(10)
1977/78	—		(1,550,800)	(3,832,000)	(10)

[1] IR–8 planted during boro (winter-spring) season.
[2] IR–20 received from commercial sources in the Philippines.
[3] Imported from India; 470 M.T. of Jaya and 231 M.T. of IR–8.
[4] "In 1972, the Bangladesh Government imported about 7,000 M.T. of IR–20 seed from the Philippines, which is the largest consignment of rice seeds ever imported by any country" (ref. 5).
[5] IR–20 exported from the Philippines in 1973. (Details on the introduction and use of IR–20 are provided in ref. 11).
[6] IR–20; imported from India.
[7] The approximate seasonal distribution of the HYV area was:

	Aus (spring-summer)	Aman (summer-fall)	Boro (winter-spring)	Total
		Percent		
1968/69	4.3	1.3	94.4	100
1969/70	6.6	4.5	88.9	100
1970/71	7.0	17.6	75.4	100
1971/72	7.8	40.6	51.6	100
1972/73	6.2	52.4	41.4	100
1973/74	8.6	53.4	38.0	100
1974/75	19.6	34.7[a]	45.7	100
1975/76	22.7	35.9[a]	41.4	100
1976/77	27.5	31.8[a]	40.7	100

[a] See fn. 8 below.

[8] The Aman HYV area subsequently was found to be overestimated for at least three years (see Appendix C).
[9] A review of experience with the HYV's through 1975/76 is provided in ref. 12.

References

(1) Letter from Leon F. Hesser, Assistant Director of Agricultural Policy, USAID, Rawalpindi, October 9, 1969.
(2) *Rice and Wheat in Pakistan*, Spring Review (AID), March 17, 1969, pp. 2–5.
(3) Barker (October 1970). Also see Foreign Agricultural Service Report PK–1032 from Islamabad, May 14, 1971.
(4) Data provided by Robert C. Tetro, Assistant Agricultural Attaché, American Embassy, New Delhi, November 28, 1975, February 6, 1978 (data from National Seeds Corporation).
(5) *IRRI Annual Report for 1972*, p. 1 (source of quote); data provided by Randolph Barker of IRRI, January 1974.
(6) "Country Field Submission: Pakistan, FY 1971," AID, August 1969, Appendix A, table 1; letter from Carl O. Winberg, Agricultural Attaché, American Embassy, Rawalpindi, October 7, 1969.
(7) *Bangladesh Agriculture in Statistics*, Ministry of Agriculture, Agro-Economic Research Section, Statistical Series No. 1, November 1973.
(8) Data provided by Shafial Alam, Office of Agricultural Attaché, American Embassy, New Delhi, December 1975.
(9) *Monthly Statistical Bulletin of Bangladesh*, Bangladesh Bureau of Statistics, June 1977, pp. 20–24 (attachment to FAS Report BD–7029, December 15, 1977).
(10) *The Two-Year Plan*, Planning Commission, March 1978, p. 79 (attachment to FAS Report BD–8001, April 7, 1978).
(11) Foreign Agricultural Service Report PK–1035 from Islamabad, May 21, 1971 (enclosure by Refugio I. Rochin on "Farmer's Experiences with IR–20 Rice Variety and Complementary Production Inputs: East Pakistan, Aman-1970," May 1971, 35 pp.; subsequently published in *The Bangladesh Economic Review*, January 1973, pp. 71–94). Buford H. Grigsby, "Introduction of IR–20 Rice Into East Pakistan," USAID, Dacca, January 14, 1972, 12 pp.
(12) *Workshop on Experience with HYV Rice Cultivation in Bangladesh*, Bangladesh Rice Research Institute, November 1976, 157 pp.

Table 22—Burma: HYV Rice

Crop year	Quantity of seed imported		Area planted or harvested [7]	
	Metric tons		*Hectares*	*Acres*
1966/67	0.1 [1]	(1)	8	19 [8] (3)
1967/68	200 [2]	(1)	3,400	8,500 [8] (3)
1968/69	— [3]		166,900	412,400 [8] (3)
1969/70	200 [4]	(2)	143,000	353,300 [8] (4)
1970/71	100 [5]	(2)	190,900	471,800 [8] (4)
1971/72	—		185,100	457,300 [8] (4)
1972/73	—		199,200	492,200 [8] (4)
1973/74	—		245,600	606,800 [8,9] (5)
1974/75	—		309,900	765,700 [8,9] (5)
1975/76 [6]	—		320,900	793,000 [8,9] (5)
1976/77 [6]	—		349,000	862,400 [8,9] (5)

[1] IR–8 imported from IRRI in 1966.
[2] IR–8 imported from the Philippines in 1967.
[3] IR–8, IR–5; less than 0.1 M.T. of each imported from IRRI in 1968.
[4] IR–5 imported from the Philippines in 1969.
[5] IR–20 imported from the Philippines in 1970.
[6] "Provisional actual" (1975/76); "Provisional" (1976:77).
[7] Area harvested ("matured acreage").
[8] The varietal composition was as follows:

	Yagyaw 1[a] (IR–8)	Yagyaw 2 (IR–5)	C4–63	Ngwetow[b]	Total
			Percent		
1966/67–1968/69	100.0	—	—	—	100
1969/70	90.3	3.3	—	6.4	100
1970/71	5.3	86.1	0.3	8.3	100
1971/72	2.6	76.9	13.1	7.4	100
1972/73	1.8	72.9	17.7	7.5	100
1973/74	—	70.3	21.5	8.2	100
1974/75	—	72.5	20.0	7.4	100
1975/76	—	76.4	14.7	8.9	100
1976/77	—	76.2	13.9	9.9	100

[a] Sown area.
[b] Ngwetoe is an improved local variety.

IR–8 was not accepted by farmers or producers. C4–63 is considered well adapted to growing conditions in upper Burma. IR–20 ("Shwewarhnan"), IR–22 ("Lonethweshwewar"), and IR–24 ("Shwewarying") were, as of August 1973, shortly to be released to farmers (ref. 6).

[9] In addition to these varieties, the following areas were planted to "other" high-yield varieties (harvested area):

	Hectares	*Acres*
1973/74	311,100	768,700
1974/75	332,700	822,200
1975/76	478,100	1,181,500
1976/77	425,300	1,050,900

This category includes an unknown quantity of other IRRI varieties, or varieties of IRRI extraction (see last sentence of fn. 8 above).

References

(1) Barker (June 1969). Also Gladys Charitz, "Rice Surplus Affirms Success," *Journal of Commerce*, March 29, 1968.
(2) Barker (October 1970).
(3) Official sources, August 4, 1970.
(4) *Report to the People, 1972–73*, Rangoon, 1973, part IV, chp. 1, par. 56; official sources, October 18, 1973.
(5) *Pyithu Hlutlaw*, Rangoon, 1977, p. 51 (forwarded by Verne R. Dickey, Commercial Officer, American Embassy, Rangoon, January 10, 1978).
(6) Moe Myint, "A Welcome by Emerald-Green Fields—3," *Working People's Daily*, Rangoon, August 10, 1973.

Table 23—India: HYV Rice

Crop year	Quantity of seed imported		Area planted or harvested		
	Metric tons		*Hectares*	*Acres*	
1964/65	— [1]	(1)	90	200 [8]	(4)
1965/66	6 [2]	(1)	7,100	17,650 [9]	(1)
1966/67	80 [3]	(1)	888,400	2,195,200 [10]	(5)
1967/68	20 [4]	(2)	1,785,000	4,410,700 [10]	(5)
1968/69	— [5]	(3)	2,681,000	6,624,800 [10,11,12]	(5)
1969/70	— [6]	(3)	4,253,600	10,510,500 [12]	(5)
1970/71	— [7]	(3)	5,454,000	13,476,700 [12]	(5)
1971/72	—		7,199,400	17,789,800 [12]	(5)
1972/73	—		8,167,400	20,181,700 [12]	(6)
1973/74	—		9,717,500	24,011,900 [12]	(6)
1974/75	—		10,779,600	26,636,400 [12]	(6)
1975/76	—		12,742,000	31,485,500 [12,13]	(7)
1976/77	—		13,731,000	33,929,300 [14]	(7)
1977/78	—		(15,000,000)	(37,065,000) [15]	(7)

[1] Taichung Native–1, hereinafter noted as TN–1. Two kg. were taken to India in a suitcase by the manager of the National Seeds Corporation.

[2] TN–1. One M.T. was shipped by air freight from IRRI in June 1965. Another 5 M.T. were received by ship from Taiwan in October 1965.

[3] TN–1. Gift of Joint Commission for Agricultural Reconstruction in Taiwan.

[4] IR–8. (from IRRI). Ten M.T. were provided by the Ford Foundation and arrived in mid-December 1966. The other 10 M.T. were provided by the Rockefeller Foundation and arrived in Calcutta in February 1967.

[5] Less than 0.1 M.T. of IR–5 from IRRI in 1968.

[6] Import of less than 0.1 M.T. each of IR 5–81 and IR 5–114 from IRRI in 1969. (Neither is an official variety, but rather a selection.)

[7] Import of less than 0.1 M.T. each of IR–20 and IR–22 from IRRI in 1970.

[8] ADT–27.

[9] Composed of ADT–27 (14.2 percent) and TN–1 (85.8 percent). Of the ADT–27 area, virtually all was in the rabi (winter) season.

[10] The approximate seasonal distribution was:

	Rabi (winter)	Kharif (summer)	Total
		Percent	
1966/67	43	57	100
1967/68	38	62	100
1968/69	29	71	100

[11] Within the rabi season, IR–8 accounted for about 49 percent of the area harvested, TN–1 22 percent, and ADT–27 and others 28 percent (ref. 8).

[12] The distribution of this area by state was:

	Andhra Pradesh	Tamil Nadu	Uttar Pradesh	West Bengal	Others	Total
			Percent			
1966/67	31.0	17.2	7.8	3.0	41.1	100
1967/68	19.0	24.8	8.4	7.9	39.9	100
1968/69	7.6	23.8	12.3	9.9	46.2	100
1969/70	12.3	26.8	13.2	10.8	36.9	100
1970/71	9.9	33.4	12.4	9.7	34.6	100
1971/72	10.1	31.2	13.8	9.8	35.1	100
1972/73	14.7	27.5	11.3	8.4	38.1	100
1973/74	18.6	22.1	10.1	8.1	41.1	100
1974/75	22.4	17.3	13.2	8.1	39.0	100
1975/76	18.5	17.0	12.2	8.9	43.4	100
1976/77[a]	17.5	16.0	12.0	9.4	45.1	100

[a] Estimated achievement.

[13] Although statistics are not available on the varietal and seasonal breakdown on a national basis, data have been obtained for the two major states. The four major varieties in Andhra Pradesh (1975/76), as a proportion of the total HYV area in the state, were: Mahsuri 28.7, RP 4–14 17.1, Tella Hamsa 16.9, and Jaya 7.9. The leading variety in Tamil Nadu (1976) was IR–20, accounting for 50.4 percent of the area; IR–8 was grown on another 2.6 percent. Other leading varieties were Ponni (Mahsuri), ADT–31, Kannagi, and Bhavani. The seasonal breakdown in Andhra Pradesh was: kharif 64 percent, rabi 36 percent. The comparable breakdown in Tamil Nadu was: kharif 38.5 percent, rabi 61.5 percent. (ref. 9.)

[14] Preliminary.

[15] Target.

References

(1) Carroll P. Streeter, *A Partnership to Improve Food Production in India,* The Rockefeller Foundation (undated: 1969 or 1970), pp. 26–29.

(2) *Ibid.*; letter from Streeter, April 14, 1970; letter from Randolph Barker, IRRI, March 31, 1970.

(3) Barker (October 1970).

(4) "Rice Crop Proves Tanjore Program's Worth," *Foreign Agriculture,* March 4, 1968, p. 7; Department of State Airgram A–44 from Madras, October 14, 1967.

(5) Foreign Agricultural Service Report IN–5027 from New Delhi, May 14, 1975.

(6) Foreign Agricultural Service Report IN–7037 from New Delhi, May 13, 1977.

(7) Data provided by Robert C. Tetro, Assistant Agricultural Attaché, American Embassy, New Delhi, February 6, 1978, March 3, 1978 (data from *Fertilizer Statistics, 1976–77,* Fertilizer Association of India, December 1977, pp. II–78 to II–84).

(8) "Evaluation Study of High-Yielding Varieties Programme, Report for the Rabi 1968–60–Wheat, Paddy, and Jowar," Planning Commission, New Delhi, November 1969, p. 50.

(9) Estimates assembled and provided by R. Seetharaman, All-India Coordinated Rice Improvement Project (AICRIP), Hyderabad, February 21, 1978; letters from Seetharaman, March 29, 1978, April 28, 1978.

Table 24—Indonesia: HYV Rice

Crop year	Quantity of seed imported	Area planted or harvested[8]		
	Metric tons	*Hectares*	*Acres*	
1966/67	0.2[1] (1)	—	—	
1967/68	—	—	—	
1968/69	1 [2] (2)	198,000	489,900	(6)
1969/70	—	831,000	2,054,000	(5)
1970/71	— [3] (3)	902,600	2,230,400	(5)
1971/72	—	1,332,900	3,293,700	(5)
1972/73	1 [4] (4)	1,928,000	4,764,200	(5)
1973/74	1 [5] (5)	3,100,800	7,662,000	(5)
1974/75	2 [6] (5)	3,440,000	8,500,200 [9]	(7)
1975/76	—	2,633,800	6,508,000 [9,10]	(8)
1976/77	1 [7] (8)	3,428,900	8,472,700 [9]	(8)

[1] 200 kg. (440 lbs.); introduced from IRRI in 1966. "There have been additional imports of small lots of seed but they have probably not exceeded one metric ton" (ref. 1).

[2] C4–63; developed at the College of Agriculture at the University of the Philippines; imported in first 6 months of 1968.

[3] 100 kg. (220 lbs.) each of IR–20 and IR–22 were introduced in January 1969 and February 1970, respectively, with USAID assistance.

[4] One metric ton of IR–20 from IRRI.

[5] 1,000 kg. (0.5 M.T.) of IR–20 and 5 kg. of IR–26. Imported by the Central Research Institute for Agriculture and the Ministry of Agriculture.

[6] 1,020 kg. of IR–28; 1,020 kg. of IR–30; and 20 kg. of 2061. Imported by the Central Research Institute for Agriculture and the Ministry of Agriculture.

[7] 500 kg. of IR–36; 500 kg. of IR–38.

[8] The seasonal distribution was as follows:

	Dry (Apr.-Sept.)	Wet (Oct.-Mar.)	Total
		Percent	
1968/69	9.1	90.9	100
1969/70	36.8	63.2	100
1970/71	27.3	72.7	100
1971/72	31.2	68.8	100
1972/73	26.8	73.2	100
1973/74	29.4	70.6	100
1974/75	34.7	65.3	100
1975/76[a]	22.9	77.1	100
1976/77[a]	42.2	57.8	100

[a] The proportions for 1975/76 and 1976/77 were derived from adjusted data (see fn. 10).

[9] The varietal breakdown was as follows:

	1974/75	1975/76	1976/77
		Percent	
"Old"			
Pelita I–1	34.9	37.7	17.5
Pelita I–2	11.5	6.9	4.3
PB–5 (IR–5)	30.8	20.8	8.7
PB–8 (IR–8)	3.0	2.4	0.6
C4–63	17.7	13.2	7.8
IR–20	2.0	3.6	3.7
"New"			
IR–26	—	15.3	34.9
IR–28	—	*	4.7
IR–30	—	*	10.9
IR–34	—	*	6.6
IR–36	—	*	*
Total	100	100	100

*Less than 1 percent.

The proportions for 1975/76 and 1976/77 were derived from unadjusted data (see fn. 10). The brown planthopper (known locally as wereng), a vector of grassy stunt virus, caused considerable damage during the mid-1970's (see *The IRRI Reporter*, No. 2, 1977, 4 pp). The newer IRRI varieties have a greater degree of resistance. During field trips to East and West Java in March and May 1978, the U.S. agricultural attaché found that an outstanding job had been done of distributing resistant varieties (IR–32, 34, 36) and that virtually no wereng damage had appeared (ref. 9).

[10] Estimate includes adjustment for nonreporting provinces. Starting in 1975/76, there was a substantial increase in the number of provinces not providing area estimates for "old" HYV's (see fn. 9). Richard Bernsten, an IRRI economist stationed in Indonesia, has adjusted the data for the missing provinces. The resulting figures were 22.1 percent higher in 1975/76 and 22.5 percent higher in 1976/77. Even with this correction, the 1975/76 area is 23.4 percent less than in 1974/75. Several rice specialists believe that there was no substantial drop in area in 1975/76. Some of the provinces may not have included data for their total area in that year, but there is no way to correct for this (ref. 8).

References

(1) Letter from Francis J. LeBeau, Chief, Agriculture Division, USAID, Djakarta, September 30, 1969 (data obtained from Ministry of Agriculture of the Government of Indonesia).
(2) Barker, *op. cit.* (June 1969).
(3) James E. Hawes, "Rice in Indonesia," Agriculture Division, USAID, Djakarta, May 1970, pp. 18, 19.
(4) Letter from Paul J. Stangel, Acting Food and Agriculture Officer, USAID, Djakarta, December 21, 1973 (data provided by the Director General of Agriculture).
(5) Letter from Leonard H. Otto, Food and Agriculture Officer, USAID, Djakarta, September 9, 1975. (Based on a Bimas report entitled "Additional Information on Development of Intensification Program," Fall 1974.)
(6) "Paddy Intensification Program: Indonesia," p. 15 (data provided by Badan Pengendali Bimas, Department of Agriculture, and forwarded by Peter Oram of FAO).
(7) Letter from Richard A. Morris, IRRI Representative, Cooperative CRIA-IRRI Program, Borgor, Indonesia, January 9, 1976. Similar estimates were provided by Sri Widodo, *et al.*, in "Indonesia . . .," in *Constraints to High Yields on Asian Rice Farms*, IRRI, October 1977, p. 50.
(8) Memo from Richard Bernsten, IRRI Economist, through Walter Tappan, Chief, Agricultural Development, USAID, Jakarta, April 10, 1978. Data provided by Tappan, November 17, 1977, January 17, 1978.
(9) Foreign Agricultural Service Aircomm from Gordon O. Fraser, Agricultural Attaché, Jakarta, March 29, 1978, 8 pp.; Dept. of State Telegram 5993 from Jakarta, May 9, 1978, 7 pp.

Table 25—Korea (South): HYV Rice

Crop year	Quantity of seed imported	Area planted or harvested		
	Metric tons	*Hectares*	*Acres*	
1969/70	0.6[1] (1)	—	—	
1970/71	—		Experimental	
1971/72	—	2,700	6,700	(2)
1972/73	—	187,500	463,300 [2]	(2)
1973/74	—	139,000	343,500 [3]	(2)
1974/75	—	306,900	758,300 [3]	(2)(3)
1975/76	—	274,000	677,100 [4,5]	(4)(5)
1976/77	—	533,000	1,317,000 [5,6]	(4)
1977/78	—	(660,000)	(1,730,000) [5]	(4)

[1] 12 kg. of IR 667–08 (Tongil) seed harvested in Korea were planted at IRRI for increase during the winter of 1969/70. The 600 kg. of seed shipped to Korea were increased to 100 M.T. by October 1970.

[2] An unfavorable growing season and other factors led to a number of problems. Farmers were subsidized. (See refs. 1, 5, 6 for details.)

[3] The Ministry of Agriculture and Fisheries now carries a lower area figure for this year, as follows (ref. 4):

Crop Year	Area Harvested	
	Hectares	*Acres*
1973/74	82,000	202,600
1974/75	181,000	447,300

The 1973/74 area has also been reported as 121,000 ha. (299,000 acres) (ref. 5). The reasons for the differences between these estimates and the official estimates reported earlier are not known.

[4] A new variety, Yushin (Tongil x IR1317), was released to farmers for seed multiplication during 1975/76; it has better palatability, disease resistance, and cold weather tolerance than Tongil (refs. 1, 3).

[5] The varietal breakdown was as follows (ref. 4):

	1975/76	1976/77	1977/78
		Percent	
Yushin	0.6	57.9	35.4
Tongil	96.3	26.5	10.5
Tongil (early)	1.3	9.0	9.7
Youngnam (early)	1.5	4.4	3.3
Milyang 22	—	1.3	7.1
Tongil glutinous	0.4	0.5	1.4
Milyang 21	—	0.2	18.4
Milyang 23	—	0.1	12.5
Suwon 251	—	—	0.8
Suwon 258	—	—	0.6
Iri 327	—	—	0.2
Other[a]	—	—	0.1
Total	100	100	100

[a] Principally Suwon 264.

[6] Blast was reported becoming a problem with Tongil and Yushin. They will be phased out over the next several years and replaced with Tongil-type varieties such as Milyang 21 and Milyang 23 (both IR 1317–316/IR–24) as well as Suweon 264 and Iri 327. All were developed in close cooperation with IRRI (refs. 1, 6, 7).

References

(1) "How Tongil Triggered A Korean Rice Revolution," *The IRRI Reporter*, No. 3, 1976, pp. 1–4.
(2) Dong Wan Shin and Yong Kun Shim, *The Effectiveness of the Tongil Rice Diffusion in Korea*, Office of Rural Development, Suweon, 1975, preface, p. 9.
(3) Letters from Gordon S. Nicks, Agricultural Attaché, American Embassy, Seoul, October 8, 1975, November 10, 1975.
(4) Letter from Nicks, June 12, 1978.
(5) In Hwan Kim, "The Success Story of the Korean Rice Revolution," Office of Rural Development, February 1977 (provided by Nicks), pp. 42, 93–97.
(6) Foreign Agricultural Service Report KR–3016 from Seoul, March 14, 1973, 3 pp. FAS Report KR–2017 from Seoul, March 22, 1972.
(7) Foreign Agricultural Service Report KR–7014 from Seoul, August 17, 1977; letter from Nicks, January 19, 1978.

Table 26—Malaysia (West): HYV Rice

Crop year	Quantity of seed imported	Area planted or harvested[4]	
	Metric tons	*Hectares*	*Acres*
1965/66	3[1] (1)	42,300	104,450 (3)
1966/67	3[2] (1)	62,700	155,000 (4)
1967/68	—	90,700	224,200 (4)
1968/69	—	96,100	237,500 [5] (4)
1969/70	—	132,400	327,100 [5] (4)
1970/71	—[3] (2)	164,600	406,600 [5] (4)
1971/72	—	197,400	487,900 [5] (5)
1972/73	—	212,200	524,400 [5] (5)
1973/74	—	217,000	536,300 [5] (5)
1974/75	—	213,200	526,900 (6)
1975/76	—	222,300	549,300 (6)
1976/77	—	NA	NA

[1] IR–8 imported from IRRI in 1966.

[2] IR–8 imported from IRRI in 1967.

[3] Less than 1 M.T. each of IR–20 and IR–22 imported from IRRI in 1970.

[4] Area harvested through 1971/72; planted area in subsequent years. Off-season (second) wet rice crop. Includes a number of HYV's. The introduction dates of the main varieties were: Malinja, early 1950's; Mahsuri, January 1965; Ria (IR–8), late 1966; Bahagia (IR–5 type), 1968; Murni (Bahagia x Ria), 1972; Marisa, 1972; Padi Jaya (C4–63 type), 1973; Sri Malaysia Satu (1) (IR–5 type), 1974; Sri Malaysia Dua (2), 1974; and Pulut Malaysia Satu, 1974. Further details on these varieties may be found in table 3 and the FAS reports listed in ref. 7 below.

[5] The varietal breakdown was as follows:

	Mahsuri	Bahagia (IR–5 type)	Malinja/ Mat Kandu[b]	Jaya (C4–63)	Ria (IR–8)	Others	Total
			Percent				
1968/69	63.0	13.9	4.9	—	6.8	11.5	100
1969/70	39.7	49.5	1.1	—	2.1	7.6	100
1970/71	30.9	38.1	4.8	—	3.1	23.2	100
1971/72	39.5	43.0	3.3	—	1.5	12.7	100
1972/73	42.8	25.3	10.2	12.3	1.2	8.2	100
1973/74	31.4	17.4	13.5	9.5	0.6	27.6	100
1974/75[a]	28.5	14.2	26.4[b]	7.0	0.4	23.5[c]	100
1975/76[a]	21.5	9.0	27.1[b]	7.4	0.3	34.7[c]	100

[a] Based on ref. 8.

[b] Malinja is known locally as Mat Candu (ref. 5). In 1974/75, the two, however, began to be reported separately. The respective proportions were (in percent):

	Mat Candu	Malinja	Total
1974/75	26.1	0.4	26.5
1975/76	27.0	0.1	27.1

[c] Starting in 1974/75, separate data became available on the following varieties included in this figure (in percent):

	Apollo	Sri Malaysia 1&2	Murni
1974/75	4.4	0.5	0.6
1975/76	3.7	1.9	0.7

References

(1) Barker (June 1969).

(2) Barker (October 1970).

(3) Letter from Dale K. Vining, Agricultural Attaché, American Embassy, Kuala Lumpur, September 4, 1969 (estimate made by Attaché's office).

(4) Letters from Gordon S. Nicks, Agricultural Attaché, American Embassy, Kuala Lumpur, October 11, 1973 and January 11, 1974. (Data from Extension and Advisory Services Division, Federal Department of Agriculture.)

(5) Letters from John S. DeCourcy, Agricultural Attaché, American Embassy, Kuala Lumpur, October 3, 1975 (data from Economic/Statistical Section, Federal Ministry of Agriculture and Rural Development), November 6, 1975.

(6) Letter from Robert V. Svec, Agricultural Attaché, American Embassy, Kuala Lumpur, February 9, 1978.

(7) Foreign Agricultural Service Reports from Kuala Lumpur: AGR–40, March 2, 1964; AGR–36, January 1, 1965; AGR–7, August 19, 1966; AGR–69, September 10, 1968; MY–2009, March 14, 1972; MY–3017, September 25, 1973; and MY–4016, September 5, 1974.

(8) Foreign Agricultural Service Telegram TOFAS 47 from Kuala Lumpur, March 24, 1978.

Table 27—Nepal: HYV Rice

Crop year	Quantity of seed imported	Area planted or harvested	
	Metric tons	*Hectares*	*Acres*
1968/69	60.6 [1] (1)(2)	42,500	105,100 [4] (2)
1969/70	75 [2] (2)	49,800	123,000 [4] (2)
1970/71	0.5 [3] (1)	67,800	167,600 [4] (2)
1971/72	—	81,600	201,700 [4] (3)
1972/73	1 (3)	177,300	438,000 [4] (3)
1973/74	—	205,100	506,800 [4] (4)
1974/75	—	222,600	550,100 [4] (4)
1975/76	—	216,400	534,700 [5] (5)
1976/77	—	220,300	544,300 [5] (5)

[1] Import of 60 M.T. of IR–8 from India and 0.6 M.T. of IR–5 from IRRI.
[2] Import of 75 M.T. of IR–8 from India.
[3] Import of 0.32 M.T. of IR–20 and 0.19 M.T. of IR–22 from IRRI in 1970 (Nepalese data list the quantities as 0.14 and 0.09 M.T., respectively; ref. 2).
[4] All improved rice.
[5] Chainan 2, Taichung Native 1, Chainung 242, Tainan 1, Kaohsiung 176, Taichung 176, IR–8, IR–20, IR–22, IR–24, Jaya, CH–45, Masuri. Excludes improved local varieties.

References

(1) Barker (October 1970).
(2) Letter from Raymond E. Fort, Food and Agricultural Division, USAID, Kathmandu, October 13, 1971 (data from Economic Analysis and Planning Division, Ministry of Food and Agriculture).
(3) Letter from Philip D. Smith, Chief, Food and Agriculture Division, USAID, Kathmandu, October 17, 1973 (data from Department of Agriculture).
(4) Letter from John R. Wilson, Chief, Office of Agriculture, USAID, Kathmandu, October 9, 1975 (data from Department of Agriculture).
(5) Letter from Wilson, January 31, 1978 (data from Department of Agriculture).

Table 28—Pakistan: HYV Rice

Crop year	Quantity of seed imported	Area planted or harvested		
	Metric tons	*Hectares*	*Acres*	
1966/67	2 [1] (1)	80	200 [3]	(2)
1967/68	77 [2] (1)	4,000	10,000 [1]	(2)
1968/69	—	308,000	761,000 [4]	(2)(3)
1969/70	—	501,400	1,239,000	(4)
1970/71	—	550,400	1,360,000	(5)
1971/72	—	728,500	1,800,000 [5]	(5)
1972/73	—	647,100	1,599,000 [5,6]	(6)
1973/74	—	636,600	1,573,000 [5,6]	(6)
1974/75	—	630,900	1,559,000 [5,6]	(7)
1975/76	—	665,300	1,644,000 [5]	(8)
1976/77	—	677,900	1,675,000 [5,7]	(8)

[1] IR–8.

[2] IR–8; 50 M.T. were imported directly from Los Banos and another 27 M.T. were forwarded from Bangladesh, where they were produced during the 1966/67 season.

[3] "Few hundred acres."

[4] Includes a "few thousand" acres of "IR–6" (Mehran 69) in the Hyderabad region; Meheran is a cross between Siam 29 and Dee-geo-woo-gen (one of the parents of IR–8).

[5] The distribution of production by province was:

	Sind	Punjab	Baluchistan	NWFP	Total
			Percent		
1971/72	68.6	28.6	2.1	0.7	100
1972/73	76.4	19.5	3.6	0.5	100
1973/74	74.4	20.0	3.4	2.3	100
1974/75	75.3	17.6	5.0	2.1	100
1975/76	78.4	17.5	2.3	1.8	100
1976/77	76.9	19.6	2.0	1.5	100

Principally "IR–6" (Mehran 69); some IR–8.

[6] The decline in HYV area in 1972/73 and its subsequent leveling off was due to several factors. The most important is that the procurement price for basmati rice, which is principally raised in the Punjab and exported, was about twice as high as for the HYV's. In addition, basmati is less demanding in terms of water, fertilizer, and plant protection requirements. A shortage of water in 1972/73 and flood damage in 1973/74 also reduced HYV area (ref. 9).

[7] A new dwarf variety, PK–177, was developed at the Rice Research Institute at Kala Shah Kaku (Punjab) and was approved in April 1977 for use in the Sahiwal District. PK–177 was developed from a cross of Basmati 27 x (IR–8 x Basmati 370). (The latter cross is sometimes referred to as IR–670, but this designation appears to be in error) (ref. 10).

References

(1) "Rice and Wheat in Pakistan," Spring Review (AID), March 1969, pp. 16–17.

(2) Letter from Leon F. Hesser, Assistant Director of Agricultural Policy, USAID, Rawalpindi, October 9, 1969.

(3) Foreign Agricultural Service Telegram TOFAS 96 from Rawalpindi, October 15, 1969.

(4) "Notification," Government of Pakistan, Ministry of Agriculture and Works, Islamabad, November 11, 1970, p. 1 (enclosure to Foreign Agricultural Service Report PK–0091 from Islamabad, November 24, 1970).

(5) Data provided by S. M. A. Jafri, Statistical Officer, Planning Unit, Ministry of Agriculture and Works, Agriculture Wing, Islamabad, December 5, 1973.

(6) Letter from Alvin E. Gilbert, Agricultural Attaché, American Embassy, Islamabad, October 2, 1975. The 1972/73 and 1973/74 data were obtained from the Planning Unit of the Ministry of Agriculture.

(7) Foreign Agricultural Service Report PK–5023 from Islamabad, November 18, 1975, p. 5.

(8) Foreign Agricultural Service Telegram TOFAS 48 from Islamabad, April 12, 1978.

(9) Letter from Gilbert, January 12, 1976.

(10) Foreign Agricultural Service Reports from Islamabad: PK–7014, May 20, 1977, p. 5; PK–8003, February 16, 1978, p. 5. Letter from Gilbert, March 27, 1978. Conversation with Ronnie Coffman of IRRI, April 7, 1978.

Table 29—Philippines: HYV Rice

Crop year	Quantity of seed imported	Area planted or harvested		
	Metric tons	*Hectares*	*Acres*	
1966/67	55.3 [1] (1)	82,600	204,000	(3)
1967/68	6.1 [2] (1)	701,500	1,733,406 [6,7]	(4)
1968/69	18.2 [3]	(1,011,800)	(2,500,000) [6,7,8]	(4)
1969/70	— [4] (2)	1,353,900	3,345,500 [6,7,9]	(4)
1970/71	34.4 [5] (2)	1,565,400	3,868,100 [6,7]	(4)
1971/72	—	1,826,800	4,514,000 [6,7]	(4)
1972/73	—	1,679,900	4,151,000 [6,7]	(4)
1973/74	—	2,176,600	5,378,400 [6,7]	(4)
1974/75	—	2,175,000	5,374,400 [6,7]	(5)
1975/76	—	2,299,600	5,682,300 [6,7]	(5)
1976/77	—	2,416,700	5,971,700 [6,7]	(5)

[1] IR–8 purchased from IRRI in July 1966 and planted in dry season in late 1966 and early 1967.

[2] 5.2 M.T. IR–8 and 0.9 M.T. IR–5 (from IRRI).

[3] 0.1 M.T. IR–8 and 18.1 M.T. IR–6 (from IRRI).

[4] Less than 0.1 M.T. each of IR–8, IR–5, IR–20, and IR–22 from IRRI in 1969.

[5] Composed of 9.5 M.T. of IR–20 and 24.9 M.T. of IR–22, both provided by IRRI in 1970. In addition, less than a M.T. each of IR–8 and IR–5 also were provided by IRRI in 1970.

[6] The HYV area is composed of three different types of varieties. Beyond the IRRI varieties, the HYV category includes: the BPI series developed by the Bureau of Plant Industry of the Philippine Government; the C series developed by the College of Agriculture, the University of the Philippines. The principal variety in the BPI series is BPI–76; it resulted from a cross between Fortuna and Seraup Besar made in 1951 and was released in 1960; other strains with less photoperiod insensitivity were released later. The principal variety in the C series is C4–63; it resulted from a cross between BPI–76 and Peta; by 1973, one of the most common strains was C4–63G. The relative areas of the various HYV series were:

	IRRI	BPI	C	Total
		Percent		
1967/68	61.1	36.3	2.6	100
1968/69	66.5	21.6	11.8	100
1969/70	76.6	8.5	14.9	100
1970/71	71.5	3.7	24.8	100
1971/72	72.1	2.8	25.1	100
1972/73	70.0	2.3	27.8	100
1973/74	71.7	2.1	26.2	100
1974/75	75.3	1.7	23.0	100
1975/76	80.5	1.4	18.1	100
1976/77	81.0	4.5	14.6	100

[7] The HYV's are raised under both irrigated and rainfed (lowland) conditions. The annual HYV breakdown is as follows:

	Irrigated	Rainfed (Lowland)	Total
		Percent	
1967/68	63.7	36.3	100
1968/69	67.5	32.5	100
1969/70	61.1	38.9	100
1970/71	62.9	37.1	100
1971/72	53.5	46.5	100
1972/73	52.0	48.0	100
1973/74	54.9	45.1	100
1974/75	51.0	49.0	100
1975/76	52.5	47.5	100
1976/77	53.2	46.8	100

[8] Unofficial estimate. The original official estimate of the Bureau of Agricultural Economics was 1,351,800 ha. (3,340,000 acres), but this seems too high in terms of: (1) the figures for the previous and subsequent year (the area devoted to HYV's was to have increased about 20 percent in 1969/70, ref. 6), and (b) another estimate available for the same year. The National Food and Agricultural Council placed the area at 579,800 ha. (1,432,600 acres) (ref. 7), or 43 percent less than the area reported in the table and 57 percent less than the BAE figure just noted.

[9] The National Food and Agricultural Council placed the area at 950,000 ha. (2,347,500 acres), or about 30 percent less (ref. 8).

References

(1) Barker (June 1969).
(2) Barker (October 1970).
(3) *Rice in the Philippines*, Spring Review (AID), March 3, 1969, section 2, p. 6, appendix table VIII-B. Data from RCPCC.
(4) Official estimates of the Bureau of Agricultural Economics, Quezon City (forwarded by Robert W. Herdt, IRRI, October 2, 1975, and David E. Kunkel, USAID, Manila, October 9, 1975, February 17, 1976).
(5) Official estimates of the Bureau of Agricultural Economics, Quezon City (forwarded by Herdt, December 15, 1977, and Kunkel, January 30, 1978). Also see S.E. Proctor, "Philippines: From Rice Importer to Exporter," *Foreign Agriculture*, April 24, 1978, pp. 3,4.
(6) Telegram from Randolph Barker, IRRI, December 14, 1970; letter from Barker, December 15, 1970.
(7) Letter from John T. Hopkins, Assistant Agricultural Attaché, American Embassy, Manila, September 25, 1970.
(8) Foreign Agricultural Service Telegram TOFAS 70 from Manila, December 3, 1970.

Table 30—Sri Lanka (Ceylon): HYV Rice

Crop year*	Quantity of seed imported	Area planted or harvested	
	Metric tons	*Hectares*	*Acres*
1967/68	0.5[1] (1)	—	—
1968/69	211 [2] (1)	7,000	17,200 [5] (3)
1969/70	— [3] (2)	26,300	65,100 [5] (4)(5)
1970/71	0.4[4] (2)	30,700	75,800 [6] (5)(6)
1971/72	—	70,900	175,300 [6] (6)(7)
1972/73	—	231,900	572,900 [6] (7)(8)
1973/74	—	368,400	910,400 [6] (8)
1974/75	—	352,100	870,000 [6] (8)
1975/76	—	331,000	817,000 [6] (9)
1976/77	—	NA	NA

* Note: The method of reporting crop years shifted between 1974/75 and 1975/76 to conform with the system used in Sri Lanka. In 1974/75, Yala 1974 was combined with Maha 1974/75 (the same practice was followed in prior years). In 1975/76, Maha 1975/76 was combined with Yala 1976; similarly, in 1976/77, Maha 1976/77 was combined with Yala 1977. Thus, in making the conversion, Yala 1975 was not reported.

[1] IR–8 (from IRRI).

[2] IR–8. In 1968, 210 M.T. of IR–8 were imported from the Philippines and 0.90 M.T. (0.45 IR–8 and 0.45 IR–5) from IRRI.

[3] In 1969, less than 0.1 M.T. of IR–20 was imported from IRRI.

[4] In 1970, less than 0.1 M.T. of IR–20 and 0.35 M.T. of IR–22 were imported from IRRI.

[5] IR–8 and IR–262.

[6] The total HYV area was divided as follows between the main varietal groupings:

	IR series[a]	BG series[b]	LD–66	Total
		Percent		
1970/71	96.3	3.7	—	100
1971/72	41.7	58.3	—	100
1972/73	7.6	85.0	—	100
1973/74	2.3	93.9	3.8	100
1974/75	1.0	93.9	5.1	100
1975/76	0.9	95.6	3.5	100

[a] IR–8 and IR–262 (principally IR–262).

[b] BG 3–5, BG 11–11, BG 34–6, BG 34–8, and BG 94–1 (principally BG 11–11 and BG 34–8). All are semi-dwarfs. The latter three are descended from crosses with one IRRI variety as a parent. The BG varieties have been bred specifically to suit local environmental conditions and represent four specific maturing durations to suit varying climatic conditions (ref. 8).

References

(1) Barker (June 1969).

(2) Barker (October 1970).

(3) Letter from H. L. Dwelly, Acting USAID Representative, American Embassy, Colombo, October 2, 1969 (data supplied by Ministry of Agriculture and Food).

(4) Data supplied by Ministry of Agriculture and Food, Colombo, October 16, 1970 (forwarded by Michael H. Snyder, Assistant USAID Representative, Colombo, October 21, 1970).

(5) Data supplied by the Ministry of Agriculture and Lands, Colombo, December 10, 1970 (forwarded by Snyder, December 14, 1970).

(6) Data supplied by T. B. Subasinghe, Deputy Director for Agricultural Development, the Ministry of Agriculture and Lands, Colombo, December 9, 1971 (forwarded by Snyder, December 13, 1971).

(7) Data supplied by T. B. Subasinghe, *op. cit.*, January 25, 1974 (forwarded by H. Birnbaum, Acting USAID Representative, Colombo, January 28, 1974).

(8) Data supplied by P. Senarath, Agricultural Economist for S/A&L, Ministry of Agriculture and Lands, Colombo. December 8, 1975 (forwarded by Ernest Kanrich, USAID Representative, Colombo, December 10, 1975).

(8) Letter from Dr. H. Weeraratne, Central Rice Breeding Station, Batalagoda, Ibbagamuwa, Sri Lanka, January 7, 1976.

(9) Department of State Telegram 0518 from Colombo, February 3, 1978 (data provided by Department of Agriculture).

Table 31—Thailand: HYV Rice

Crop year	Quantity of seed imported	Area planted or harvested[1]		
	Metric tons	*Hectares*	*Acres*	
1969/70	—	(3,000)	(7,400) [2]	(1)
1970/71	—	(30,000)	(74,000) [2]	(1)
1971/72	—	(100,000)	(247,100) [2]	(1)
1972/73	—	(300,000)	(741,000) [2]	(1)
1973/74	—	(400,000)	(988,400) [2]	(1)
1974/75	—	(450,000)	(1,112,000) [2,3]	(1)
1975/76	—	(600,000)	(1,482,600) [2,3]	(1)
1976/77	—	(960,000)	(2,372,200) [2,3]	(2)

[1] Unofficial estimate of HYV area; official statistics not available. Principally RD series: RD–1, RD–2, RD–3, RD–4, RD–5, RD–7, RD–9; some C4–63 (see fn. 3). Details on the origin of these varieties are provided in ref. 4.

[2] The estimated seasonal breakdown was:

	Wet (June-Dec.)	Dry (Feb.-June)	Total
		Percent	
1970/71	90	10	100
1971/72	80	20	100
1972/73	40	60	100
1973/74	30	70	100
1974/75	20	80	100
1975/76	15	85	100
1976/77	17	83	100

Farmers have been reverting to traditional varieties during the wet season. Nearly all the dry season rice area is planted to HYV's.

[3] It is estimated that about 90 percent of the HYV area is planted to the RD series and about 10 percent C4–63 (mainly in the Central Plain). Within the RD series, RD–7 was the most popular as of 1977 due to its excellent milling and cooking quality. RD–9 is grown primarily in the areas where brown plant-hopper and associated virus problems are present. Both are intermediate in height. Two new RD varieties were released in 1977: RD–6, a glutinous variety which is not really a HYV in terms of yield; and RD–11 which possesses longer grain than the other RD varieties (ref. 3).

References

(1) Letters from Guy L. Haviland, Jr., Agricultural Attaché, American Embassy, Bangkok, November 5, 1975, December 11, 1975. (Estimates provided by Dr. Ben R. Jackson, Rockefeller Foundation, Bangkok.)

(2) Letters from Cline J. Warren, Agricultural Attaché, American Embassy, Bangkok, November 22, 1977 (estimate developed in cooperation with Ben R. Jackson of the Rockefeller Foundation, Bangkok).

(3) Letter from Ben R. Jackson, Rockefeller Foundation, Bangkok, December 16, 1977.

(4) For early details on the Thai breeding program, see: Delane Welsch and Sopin Tongpan, "Background to the Introduction of High-Yielding Varieties of Rice in Thailand," University of Minnesota, Department of Agricultural and Applied Economics, Staff Paper 72–6, February 1972, pp. 21–25; and the articles on dwarf varieties by B. R. Jackson, *et al.*, and A. C. Yantasast, *et al.*, in the *Thai Journal of Agricultural Science:* 1969, pp. 83–92; 1970, pp. 119–133. More recent information is provided in "Brief History of the RD Series of Rice Varieties Developed in Thailand from 1969 to 1975," Rice Division, Department of Agriculture, Bangkok, 1976, 6 pp. (provided by Ben R. Jackson).

COMMUNIST NATIONS OF ASIA

This section includes information of the use of HYV's in three Asian nations: the People's Republic of China (PRC), Laos, and the Socialist Republic of Vietnam (formerly North and South Vietnam).

In Laos and South Vietnam, the introduction and early use of HYV's was facilitated by technical assistance programs of the U.S. Agency for International Development. Thus, we have relatively complete data on these countries through the early 1970's—which was reported in the form of statistical tables in earlier editions. No comparable statistical information on HYV's is available for subsequent years.

In the other two nations, the PRC and North Vietnam, somewhat scattered information was available which was summarized in narrative form. Recently, considerably more information became available on the PRC, which permits considerably expanded coverage. Relatively little additional information has been found on North Vietnam and what is now the Socialist Republic.

Nothing is known of the use of HYV's in Cambodia.

China (People's Republic)

China has long been the world's largest rice producer. Accordingly, it has the longest history of rice improvement and progressive cultivation.[1] As in other countries, much improvement occurred as farmers simply selected improved varieties which were then used locally. The major characteristics of this process were outlined in Chapter II.

Both indica and japonica (sinica or keng) rices are found in China. Most varieties grown in southern China traditionally have been indicas. Both types are grown in the area bordering the Yangtze River in east China.[2]

Irrigation and fertilization of rice have long been practiced in China. Through most of history, the fertilizers were organic products such as compost, green manures, oil meals, fish cakes, and night soil. The development of quick-acting chemical fertilizers promised a much sharper boost for varieties which could respond to their application and yet not lodge. Such fertilizers, however, were not widely adopted in China until the 1960's.[3] They subsequently had a significant effect on agricultural production. Fertilizer-responsive rice varieties also played a key role.[4]

Stalk strength is a particularly important factor in the southern portions of China, especially Kwangtung Province, because the crop matures during the first part of the typhoon season. Two indica sources of dwarfing were identified

[1] T.T. Chang, "The Rice Cultures," *Philosophical Transactions of the Royal Society of London*, Series B, July 27, 1976 (Vol. 275, No. 936), pp. 143–157.

[2] T. H. Shen, *Agricultural Resources of China*, Cornell University Press, 1951, p. 197.

[3] Dwight H. Perkins, *Agricultural Development in China, 1368–1968*, Aldine, Chicago, 1969, pp. 60–76.

[4] Dwight H. Perkins, "Constraints Influencing China's Agricultural Performance," Harvard University, Institute of Economic Research, Discussion Paper No. 407, April 1975, pp. 15, 18. (Also published under the same title in *China: A Reassessment of the Economy*, U.S. Government Printing Office, Washington, 1975.)

in Kwangtung in the 1950's: Ai-chiao-nan-te, and Ai-tze-chuan. They have subsequently become the source of the dwarfing gene for virtually all of the dwarf varieties raised in China.[5] While it is claimed that the dwarfing genes of the two varieties differ, IRRI scientists now believe the rices share the same dwarfing gene and that it is the same one present in the IRRI semi-dwarf varieties (see Chapter II).

Current accounts of the origin of these two varieties vary somewhat (each recent delegation seems to have gotten a slightly different version; problems of translation and transliteration complicate the process). A tentative summary follows:

AI-CHIAO-NAN-TE.—Several recent IRRI groups were told that this variety was discovered by two farmers in eastern Kwangtung in 1956 in a field which was otherwise flattened by a typhoon. This selection was then, according to one team, placed in production in 1958–59. The other team understood that it was rapidly multiplied and released as a variety under the above name in 1957.[6] One of the teams, however, also heard suggestions that Ai-chiao-nan-te may have been developed from a cross with Ai-tze-chuan.[7] An earlier reference states that distribution of a dwarf "Nanteh" variety (I-geo-nan-teh) began in 1961.[8] In any case, Ai-chiao-nan-te and its progeny now seem to be considerably less important than Ai-tze-chuan.

AI-TZE-CHUAN.—Two recent IRRI teams learned that this variety was identified from germ plasm, said to be from Kwangsi Province, at Kwangtung Agricultural Academy in 1956.[9] An earlier group was told that the variety had been found in a farmer's field in the same year.[10] It was crossed with a local variety of normal height (Kuang Chang 13) and in 1959 one of the selections from that cross, Kuang-chang-ai, was released. Other offspring of Ai-tze-chuan subsequently released include Chen-chu-ai (1961), and Che-yi-chiang and Kwan-lu-ai (early 1960's).[11] Through these and other offspring, Ai-tze-chuan has become the major dwarfing source for most of the important varieties raised in China.

In addition, the province of Fukien appears to have played a role in the development of semi-dwarf rice. It is reported that at least some of the short-stalk strains developed in eastern Kwangtung were from a parent variety native to Fukien Province.[12] Similarly, to the immediate north in Kiangsi Province, a short-stemmed rice (Bantam Nan 4) was introduced from Fukien in early 1964.[13]

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[5] A 1965 paper identifies a third semi-dwarf type, Tien-chi-dou, but it has not been mentioned subsequently (T.T. Shen, T.T. Lu, and J.S. Li, "A Genetical Analysis of Some Characters in Breeding Early-Maturing Short-Strawed Rice Types" (in Chinese), *Xuowu Xuebao* (*J. Crop. Sci.*), 1965, 4(4), pp. 391–402 (provided by Dr. T.T. Chang of IRRI).

[6] Based on: W.R. Coffman, H.E. Kauffman, and E.A. Heinrichs, "Summary Report; Visit of the IRRI Rice Improvement Team to the People's Republic of China, August 15–30, 1977," 1978, pp. 6–19; *Rice Research and Production in China: An IRRI Team's View*, IRRI, 1978, p. 62. A similar version of the 1956 discovery was provided for an unnamed variety in Foreign Agricultural Service Report HK-2036 from Hong Kong, June 2, 1972, p. 4.

[7] Coffman, *et al., op. cit.*, p. 12.

[8] Based on comments provided by Yeuh Tung, Office of the Agricultural Office, American Consulate General, Hong Kong, September 23, 1970.

[9] Coffman, *et al., op. cit.*, p. 10; *Rice Research . . ., op. cit.*, p. 62.

[10] *Plant Studies in the People's Republic of China: A Trip Report of the American Plant Studies Delegation.* National Academy of Sciences, Washington, 1975, p. 52.

[11] Coffman, *et al., op. cit.*, pp. 10, 11; *Rice Research . . ., op. cit.*, p. 62; *Plant Studies . . ., op. cit.*, p. 52. The latter report suggests a 1960 release date (pp. 44, 52).

[12] Tung, *op. cit.*

[13] "Kiangsi Farmers Experiment, Improve Crops," transcription of radio broadcast on September 26, 1969, FBIS No. 197, October 10, 1969, p. C 4.

Dee-geo-woo-gen, one of the parents of TN-1 and IR-8, is thought to have come from Fukien.[14]

Large-scale dissemination of dwarf, high-yielding varieties began in 1964. By 1965, a total of about 4.3 million ha. (10.6 million acres) reportedly were planted. This was 13 percent of the total rice area in the country. The main varieties were: Nung-k'en 58 (26 percent of the total), Chen-chu-ai (17 percent), Ai-chiao-nan-t'e (17 percent), and others (40 percent). Adoption of these varieties (with Chiang-nan-ai substituting for Nung-k'en 58) was particularly rapid in Kwangtung. By 1965, about 1.5 million ha. (3.7 million acres) reportedly were sown; this accounted for two thirds of the early crop. In Kiangsu, about 0.63 million ha. (1.6 million acres) were planted to Nung-k'en 58 in 1965. High-yielding varieties also were heavily planted in Fukien and Hunan provinces.[15]

The subsequent role of improved varieties appears to have been substantial. Some accounts indicated that they continued to be extensively planted in Kwangtung in the late 1960's.[16] Several radio accounts and visitors in 1969 mentioned dwarf, high-yielding varieties.[17] Record rice yields reported in China in 1969 were attributed to the introduction of new varieties.[18] By 1970, dwarf varieties reportedly were used extensively in all early rice-producing provinces (the area of early rice accounts for about one-quarter of the total rice output in China).[19] In late 1974, the Chinese Academy of Agricultural and Forestry Sciences indicated that 80 percent of the rice grown in south China is short statured and stiff-strawed.[20] It has been suggested that, as of 1973, a total of 6.7 million ha. (16.6 million acres) were planted to high-yielding varieties.[21]

One of the more dramatic recent accomplishments is the development of hybrid rices.[22] Work was begun in 1964 at the Chienyang (Chan-yang) Agricultural School in Hunan, when a male-sterile plant was found. Maintainer lines were developed at Chienyang by 1972 and restorer lines (including IR-24 and IR-661) at Kiangsi Agricultural College in 1973. Following further testing, the hybrids were planted on 300 ha. (740 acres) in China in 1975. The area climbed to 133,000 ha. (328,600 acres) in 1976 (including 87,000 ha. in Hunan) and reportedly exceeded 2 million ha. (4.94 million acres) in 1977. As of May 1977, there were four main varieties: Nan Yu 3, Ch'ang Yu 3, Nan Yu 6, and Nan Yu 2; IR-24 is one of the parents of Nan Yu 2. About 10 other hybrids exist. The hybrids tiller vigorously, which means that the amount of seed required is reduced. Yield increases of 20 to 30 percent are reported, but in one test plot observed in August 1977, yields appeared to be less than for an IRRI

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[14] T.S. Miu (ed.), *A Photographic Monograph of Rice Varieties of Taiwan*, Taiwan Agricultural Research Institute, Special Publication No. 2, December 30, 1959, p. 67.

[15] Benedict Stavis, *China's Green Revolution*, Cornell University, East Asia Papers. No. 2, January 1974, pp. 20–27. Another source places the dwarf area in Kwangtung at nearly 1 million acres or about 400,000 ha. in 1964 (or about half the total rice area); by 1965, the dwarf area represented more than 80 percent of the total (Tung, *op. cit.*).

[16] Stavis, *op. cit.*, p. 25.

[17] Tillman Durdin, "Chinese Report New Rice Strain," *New York Times*, October 26, 1969; "Two Big Harvests Reported in China," *New York Times*, November 19, 1969.

[18] "Two Big . . .," *op. cit.*

[19] Tung, *op. cit.*

[20] *Plant Studies in the People's Republic . . ., op. cit.*, p. 48.

[21] Ben Stavis, "A Preliminary Model for Grain Production in China, 1974," *The China Quarterly*, March 1976, p. 87 (based on "New Achievements in Rice Research," *Peking Review*, February 8, 1974 p. 22).

[22] "Because rice is a self-pollinated crop, to exploit the hybrid vigor of the F1 for rice production, one must find three lines for seed production—the cytoplasmic male-sterile or A-line, the maintainer or B-line, and the fertility restorer or R-line." (Lin Shih-Cheng, "Rice Breeding in China," *International Rice Research Institute Newsletter*, October 1977 (5/77), pp. 27–28).

line grown in the same trial. Success in using hybrids depends on the ability to multiply the male-sterile lines and to mass-produce hybrid seed.[23]

Until recently, it was a tantalizing question whether the IRRI varieties played any role in recent Chinese developments. For several years, the Chinese said nothing about this and Western news accounts were mixed.[24] The first official comment was provided to the American Plant Studies Delegation, which visited China in August and September 1974. The Kwangtung Academy of Agricultural Sciences revealed that IR-8 came into that Province in 1967 and was planted in 1968. Its growing season proved too long to fit the multiple-cropping patterns of the area, and it was not sufficiently cool-tolerant or resistant to bacterial leaf blight. IR-8 has been used, however, in breeding programs because of its stiff straw and high-yielding ability. IR-8 also was said to have been introduced in Shensi Province in 1971, but again the growing season proved to be too long. Other IRRI varieties tested in Kwangtung include IR-20, IR-22, IR-24, and IR-26; none, however, fit the growing season requirements.[25] Similar IRRI variety results have been obtained in Nanking and Shanghi.

The source of several of these more recent varieties is clear: in late November 1973, Philippines President Marcos presented 1 M.T. of IR-20 and one sack of IR-26 to a visiting Chinese trade delegation. The gift was reportedly in response to a request from Premier Chou En-Lai. The delegation also visited IRRI.[26] The Director-General of IRRI received samples of Chinese rices during a visit in August 1974. This was followed by the visit of a team of Chinese scientists and administrators to IRRI in March and April 1976. More recently, teams of IRRI scientists visited China in October 1976 and in August 1977.[27]

The Chinese now have virtually all of the IRRI varieties and elite breeding lines. Essentially none, however, is raised directly at the farm level, because of the problems noted above. But the IRRI varieties are recognized to have relatively high insect and disease resistance as well as other desirable characteristics. Thus, the main contributions of the IRRI varieties in China would appear to be as parents in current and future breeding programs.

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[23] This paragraph is based on: (a) *Ibid.*, (b) notes compiled by Haldore Hanson, Director General of CIMMYT, during a briefing by Fang Tsui-nung, Deputy Secretary of the Chinese Academy of Agricultural Sciences, Peking, May 28, 1977, and a visit to a display on the subject at the National Agricultural Exhibition Hall in Peking, same date; (c) "Expanding Rice Output," *Peking Review*, Peking, October 28, 1977, p. 30 (provided by Ben Stavis, Michigan State University); (d) "Better Seed Strains," *China Reconstructs*, Peking, November 1977, p. 36, 37 (provided by Stavis); (e) "More Areas Sown to Hybrid Rice," *Peking Review*, Peking, March 3, 1978, pp. 30–31; and (f) Coffman, *et al.*, *op. cit.*, pp. 13–16. Further details on the hybrid rices are provided in Chinese in two articles in *Zhongguo Nongye Kexue* (Chinese Agr. Sci.), 1977, No. 1, pp. 21–31 (provided by Dr. T.T. Chang of IRRI).

[24] Several reporters pointed out the similarities between the IRRI and Chinese varieties, but went no further. Only one writer is known to have actually said that IR-8 was being used in China; he indicated that the Chinese began their first experiments with the seed in 1968, and then placed orders for seed through proxies in Nepal and Pakistan for spring planting in 1970. (Richard Hughes, "China Samples the Rockefeller Rice," *London Sunday Times*, February 15, 1970 [reprinted as "Superior Rice Strain Is Sold to Red China," *Chicago Tribune*, May 6, 1970]. Hughes subsequently indicated [letter, September 21, 1970] that he had confirmed the report with a contact in Peking).

[25] *Plant Studies in the People's Republic . . .*, *op. cit.*, pp. 50–53. Press accounts based on this study were reported in the *New York Times* on September 24, 1974, and October 7, 1974. Also see *The IRRI Reporter*, 4/74, pp. 1–2.

[26] "China—IRRI Rice Research," *Times Journal*, Manila, December 1, 1973, pp. 1, 10. Also see *The IRRI Reporter*, 4/74, pp. 1–2.

[27] See "Scientific Exchange With China Could Stimulate Rice Production," *The IRRI Reporter*, 1/77; pp. 1–3; Coffman, *et al.*, *op. cit.*; and *Rice Research . . .*, *op. cit.*

Table 32—Laos: HYV Rice

Crop year	Quantity of seed imported	Area planted or harvested	
	Metric tons	*Hectares*	*Acres*
1966/67	0.1[1] (1)	360	900[4] (3)
1967/68	–	1,200	3,000[4] (4)
1968/69	6 [2] (1)	2,000	5,000[4] (4)
1969/70	–	2,000	5,000[4] (5)
1970/71	10 [3] (2)	(53,600)	(132,500)[4,5] (6)
1971/72	–	30,000	74,100[4] (7)
1972/73	–	50,000	123,600[4] (7)
1973/74	–	NA	NA
1974/75	–	NA	NA

[1] IR-8 imported from IRRI in 1966.

[2] Two M.T. each of IR-5 and IR-253 (a glutinous selection specifically chosen to suit taste preferences in the upper Mekong River basin) were imported from the Philippines in 1968. Two M.T. of IR-253 came from IRRI in 1968.

[3] IR-20 from commercial sources in the Philippines. In addition, less than 0.1 M.T. each of IR-20 and IR-22 were imported from IRRI.

[4] The approximate seasonal distribution was as follows:

	Wet	*Dry*	*Total*
		Percent	
1966/67	–	100	100
1967/68	17	83	100
1968/69	25	75	100
1969/70	25	75	100
1970/71	(97)	(3)	(100)
1971/72	94	6	100
1972/73	96	4	100

[5] The increase in wet season area is exceptionally large. It may represent the theoretical area that could have been planted (ref. 8).

References

(1) Barker (June 1969).
(2) Barker (October 1970).
(3) Department of State Airgram A-647 from Vientiane, August 15, 1969.
(4) Letter from Leroy H. Rasmussen, Agriculture Division, USAID, Vientiane, September 12, 1969.
(5) Letter from Rasmussen, September 23, 1970.
(6) Department of State Telegrams from Vientiane: 00476, January 18, 1972 and 00804, January 28, 1972.
(7) Letter from Charles A. Sanders, Chief, Agriculture Division, USAID, Vientiane, October 26, 1973.
(8) Letter from Donald R. Mitchell, Deputy Chief, Agriculture Division, USAID, Vientiane, January 4, 1974.

Vietnam (Socialist Republic)

Historical review of the HYV situation in Vietnam is necessarily divided into two geographic sections: the north and the south. Following the pattern established in earlier editions of this report, the nature of the coverage also differs: that for the north is narrative, that for the south is statistical. Both basically conclude with the mid-1970's and are unchanged from the previous edition. A final short section summarizes some comments concerning the combined or Socialist Republic which emerged after April 1975.

NORTH VIETNAM.—Short-season rice strains were introduced in the mountain areas of North Vietnam in 1948. They were classified as a *spring* rice (planted in the spring and harvested in the summer), and their short growing period made it possible to plant them after the traditional fall crop (10-month rice). By 1954, some 5,000 ha. (12,400 acres) of spring rice were planted in the mountain regions.

Beginning in 1957, steps were taken to introduce spring rice into the midlands and delta areas, where the traditional fifth month rice (*chiem*) was not well suited. Early efforts were not very successful and, by 1965, the total spring rice area in North Vietnam had dropped to 3,700 ha. (9,100 acres), Thereafter, however, appropriate cultural methods were developed and the area of spring rice expanded sharply:[1]

	Hectares	*Acres*
1966	23,700	58,550
1967	25,050	61,900
1968	34,500	85,250
1969	63,250	156,250
1970	103,650	256,100
1971	540,000	1,334,300
1972	650,000	1,606,150

While the early spring varieties had a short growing season, they were not classified as high-yielding. Reportedly, *new strains* with short stems and short growth duration were "created" in 1966–1967 "after long and patient agronomical researches."[2] During the 1969/70 winter-spring season, about 18.5 percent of the spring rice area was planted to new varieties. By 1970/71, this had increased to 58 percent.[3] By the 1971/72 season, the proportion was placed at 65 to 70 percent.[4] The subsequent level of use is thought to have remained in this range. Since the spring crop accounted for about 58 percent of the annual crop, as of the mid-1970's, this means that 38 to 41 percent of the total rice area was planted to the improved varieties. In addition, some of the 10-month crop is sown to improved varieties.

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[1] "Spring Rice," *Viet Nam Courier*, Hanoi (in English), October 1972, p. 19. Other details are provided in "Spring Rice Has Good Prospects in Vietnam," *Khoa Hoc Thuong Thuc*, Hanoi (in Vietnamese), February and March 1970 (JPRS 50693, June 9, 1970).

[2] *Ibid.*, p. 20. Varieties mentioned were Tran Chau No. 2 and No. 4.

[3] "New Varieties, New Productivity," *Nhan Dan*, Hanoi (in Vietnamese), February 22, 1972, p. 2 (JPRS, 55745, April 18, 1972).

[4] "Fertilizing Rice," *Nhan Dan*, March 20, 1972, p. 2 (JPRS, 55894, May 4, 1972); "Develop Winter-Spring Production," *Nhan Dan*, March 22, 1972, pp. 1, 4 (FBIS, April 5, 1972).

Two of the most important improved varieties are Nong Nghiep (Agriculture) 5 and Nong Nghiep (Agriculture) 8. As of September 1969, the two were reported "growing experimentally over large areas." [5] A subsequent newspaper account indicated that emphasis was being placed on IR-8; the seed allegedly was obtained "through Hong Kong and elsewhere." [6] In December 1972, Nong Nghiep 8 was reported to be the predominant spring variety. [7] Both it and Nong Nghiep 5 also appear to be the principal new varieties used during the 10-month crop. [8] A new variety, A2, is "treated, selected, and nurtured from the IR-8 variety." A2 also is one of the parents of A3 and A4. [9] IR-5 and IR-8, therefore, appear to have been of considerable significance in North Vietnam.

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[5] Nguyen Van Luat, "Prospects for Short-Term Rice in Vietnamese Agriculture," *To Quoc*, Hanoi, September 1969, pp. 24–26 (JPRS, 49482, December 19, 1969).

[6] George McArthur, "N. Vietnam Reaping Record Rice Crop," *The Washington Post*, August 19, 1971, p. F2.

[7] "Seeds and Seedlings," *Nhan Dan*, December 18, 1972, pp. 1, 4 (JPRS, 58128, February 1, 1973).

[8] "Establishing the Correct Allocation of 10th Month Rice," *Nhan Dan*, May 22, 1973, p. 2 (JPRS, 59449, July 6, 1973).

[9] "Scientific and Technical Activities News Column," *Tap Chi Hoat Dong Khoa Hoc*, Hanoi, December 1972, pp. 42–43 (JPRS, 58335, February 27, 1973). This is the first direct Vietnamese reference to IR-8 observed.

SOUTH VIETNAM.—

Table 33—South Vietnam: HYV Rice

Crop year	Quantity of seed imported	Area planted or harvested			
	Metric tons		*Hectares*	*Acres*	
1967/68	45 [1]	(1)	500	1,200[8]	(1)
1968/69	2,005 [2]	(1)	40,000	98,800	(6)
1969/70	0.1[3]	(2)	204,000	504,000	(6)
1970/71	1.0[4]	(3)	502,000	1,240,400	(5)
1971/72	56.0[5]	(4)	674,000	1,665,400	(5)
1972/73	–		835,000	2,063,300	(5)
1973/74	2.0[6]	(5)	890,000	2,199,200[9]	(6)
1974/75	[7]		(900,000)	(2,223,900)[10]	(6)

[1] IR-8; imported in October 1967. This shipment is noted in an AID report (ref. 1) but not in IRRI listings (which cite only shipments of less than 0.1 M.T. of IR-8 and IR-5; ref. 7).

[2] 2,000 M.T. of IR-8, 5 M.T. of IR-5. Barker indicates that the Philippines exported 1,807 M.T. of IR-8 and 205 M.T. of IR-5 to Vietnam (ref. 7). The reason for the difference in varietal composition is not known.

[3] 143 lbs. (65 kg.) of IR-20 received from IRRI in June 1969.

[4] IR-22 from IRRI, 1970. In addition, less than 0.1 M.T. of IR-20 seed was received from IRRI.

[5] Of this, 55 M.T. were IR-20 imported from the Philippines in March 1971 (50 M.T. were distributed to farmers in flood ravaged provinces; 5 M.T. were registered seed and were distributed for certified seed production) while 1 M.T. of RD-1 was imported from Thailand as a possible replacement for IR-5 (known locally as TN-5).

[6] IR-26. 35 M.T. of certified IR-20 were exported to Cambodia in July 1973.

[7] 10 M.T. of IR-20 were exported to Cambodia in January 1975.

[8] Area planted. Only about 134 ha. (330 acres) were harvested because of poor rains.

[9] Of this total, perhaps 500,000 ha. (1,236,000 acres) were composed of IR-20. Much of the remaining area was planted to IR-5, IR-8, and C4-63.

[10] Unofficial estimate. Area planted to IR-20 dropped from previous year; replaced by IR-26 and TN 73-2 (an IRRI selection identified by Vietnamese researchers).

References

(1) *Rice in South Vietnam,* Spring Review (AID), March 12, 1969 (TOAID A-1357), pp. 2, 8, 15, 16, 17.

(2) Agricultural Production Memo, Rice Series No. 117, Office of Domestic Production, USAID, Saigon, January 6, 1970. Also noted in Department of State Airgram TOAID A-5406 from Saigon, October 31, 1970, p. 5.

(3) Barker (October 1970).

(4) Agricultural Production Memo, Rice Series No. 140, Office of Food and Agriculture, USAID, Saigon, May 25, 1971, pp. 1–5; letter from Ralph W. Clark, Agricultural Production Division, Office of Food and Agriculture, USAID, Saigon, November 20, 1971.

(5) Letter from C. T. Brackney, Agronomy Advisor, Rice, Office of Food and Agriculture, USAID, Saigon, November 7, 1973. The 1970/71 data were based on records of the Rice Service; beginning in 1971/72, data were obtained from the somewhat more conservative Directorate of Agricultural Economics.

(6) Conversations with C. T. Brackney, Washington, D.C., August 14, 15, 1975. Area data for 1973/74 from Directorate of Agricultural Economics; 1974/75 data are estimates.

Socialist Republic.—Information on the use of HYV's in the Socialist Republic of Vietnam is relatively limited. But several recent articles have cast some light on their use. Among the major HYV's commonly referred to are:

—Than Nong 20, 22, 26, 30, 73/72, 2153, and 1561.[1]

—Nong Nghiep (Agriculture) 8, 22, 73/2[2]

There is some overlap in the varietal names and numbers (22 and 73/2 appear in both categories); this may simply represent regional variation in usage.

As would be expected from the two previous sections on Vietnam, most of the current HYV's seem to be IRRI varieties or lines, or are descended from them. Nong Nghiep 5 and Nong Nghiep 8, as suggested in the section on North Vietnam, bear a strong resemblance to IR-5 and IR-8. And TN-73-2, as stated in footnote 10 of table 33 on South Vietnam, is an IRRI selection (IR 1561) identified by Vietnamese researchers. In some cases, direct reference is made to the use of IR–8, IR–20, and other IRRI varieties or lines.[3]

Further information on the Nong Nghiep varieties has recently become available. One article refers to a number of Nong Nghiep "varieties imported and domesticated by us"; they are NN 1–A, NN2–A, NN 1–B, and NN–36.[4] NN 1–A, first tested in the winter of 1975, has become the main variety grown during the early winter in Hai Hung province in the north.[5] NN 3–A was introduced in late 1977; according to an official report, it "is the name given by the Ministry of Agriculture to rice variety IR36."[6] A radio broadcast in early 1978 indicated that NN 8 represented more than 60 percent of the total 5th month spring rice planting in the north.[7]

The wet season rice situation was reviewed by the deputy director of the Agricultural Science Institute at a seminar in Bangladesh in October 1977.[8] The country has been trying to increase the area of early and mid-season varieties, both for the added yield and for sowing with the third winter crop. Some of the HYV's resistant to bacterial leaf blight, such as IR-22 and IR-1561, are providing encouraging results. IR-5 is proving useful for flooded areas where late maturing is desired. Promising new varieties are: early, X-1 (IR-8 x IR-22), expected to substitute for IR-1561; medium, V-13 (IR-8 x IR-579), and Biplab (BR-3 from Bangladesh).

A recent visitor to the Vietnamese Scientific Research Center in Hanoi found that some of the biologists were working with IRRI varieties to "produce a crop with a higher nitrogen content [higher protein] and to find a rice variety that will withstand a colder environment."[9]

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[1] "Agriculture in Southern Viet Nam Before and After Liberation," *Vietnam Courier*, Hanoi (in English), No. 57, February 1977, pp. 12, 13.

[2] "Nghia Binh Province and Its Food Problems," *Vietnam Courier* No. 59, April 1977, p. 19.

[3] "Agriculture in . . .," *op. cit.*; "Food Production—A Most Important Task, in Quang Nam—Da Nang Province," *Vietnam Courier*, No. 67, December 1977, p. 9; Dao The Tuan, "The Wet Season Rice in Vietnam," presented at the International Seminar on Photoperiod-Sensitive Transplant Rice held at the Bangladesh Rice Research Institute, October 24–28, 1977, 9 pp.

[4] *Khoa Hoc Va Ky Thuat Nong Nghiep*, Hanoi (in Vietnamese), March 1978, No. 3, pp. 163–168.

[5] "A New Rice Strain: the Nong Nghiep (Agriculture) 1–A," *Vietnam Courier*, No. 71, April 1978, pp. 14–15.

[6] *Quan Doi Nhan Dan*, Hanoi (in Vietnamese), December 12, 1977, p. 4.

[7] Hanoi Domestic Service (in Vietnamese), February 26, 1978.

[8] Tuan, *op. cit*.

[9] Alastair Hay, "Science Helps to Rebuild Vietnam," *Nature*, January 12, 1978, pp. 101, 102.

NEAR EAST

Rice is a relatively minor crop in the Near East. Egypt is the leading producer, followed by Iran, Afghanistan, and Iraq. Semi-dwarf HYV's have been used to a limited extent in Egypt, Iran, and Iraq, but evidently not in the other countries in the Near East.

Egypt

IRRI varieties have been under test in Egypt for a number of years. IR-8 was introduced in 1967, but was rejected because of relatively late maturity and unpopular grain quality. Subsequently, in 1973, IR-22 and its sister line IR 579–48 were reported to be the most promising introductions; they were undergoing final yield and seed multiplication tests.[1] By 1975, about 6,800 ha. (16,800 acres) were planted to IR-22 and IR-579.[2] Sakha 1 and Sakha 2 have been named from IRRI selections.[3] One drawback of most of the IRRI material is its greater susceptibility to the stem borer than local varieties such as Nahda. The IRRI varieties also have been used for crossing with local varieties; hybrid 236–21 is one such product.[4]

Iran[5]

The first semi-dwarf to find producer and consumer acceptance in Iran is Amol I. It was developed from a 1963 cross between Tarom Firoze Kanda (a tall local variety) and Taichung Native I. Amol I was released for cultivation in Mazandaran Province in 1973. It was planted on about 2,750 ha. (6,800 acres) in 1974 and 11,000 ha. (27,200 acres) in 1975. The Rice Research Station distributed enough seed to plant 10,000 ha. (24,700 acres) during the 1976/77 season; a larger distribution was planned but was reduced to this level because of pest problems.

Another relatively new variety which is commonly mentioned is Mehr. Mehr is an improved "Sardi" variety and is neither a semi-dwarf nor high-yielding.

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[1] M. S. Balal: "Rice Production in Egypt," "Breeding Rice Varieties for Higher Productivity," FAO/SIDA Seminar, Cairo, September 1973, pp. 73, 215.

[2] Letter from R. Gerald Saylor, The Ford Foundation, Cairo, October 29, 1975 (data from the Institute of Agricultural Economics, Ministry of Agriculture).

[3] Letter from T. T. Chang, IRRI, March 10, 1976.

[4] H. A. El-Tobgy, *Contemporary Egyptian Agriculture*, The Ford Foundation, Beirut, January 1974, pp. 107–109.

[5] Foreign Agricultural Service Report IR-5009 from Tehran, May 8, 1975, p. 3; letter from Paul Ferree, Agricultural Attaché, American Embassy, Tehran, December 20, 1977; "Development and Spread of High Yielding Varieties of Rice in Iran" (unsigned and undated note provided by Thomas R. Hargrove of IRRI, March 9, 1978).

Iraq

IR-8 was introduced into Iraq in 1969 and IR-22 in 1975. The areas planted to these two varieties in recent years are estimated to be:[6]

Crop Year	HYV area	
	Hectares	*Acres*
1972/73	5,000	12,400
1973/74	12,000	29,700
1974/75	15,000	37,100

Both varieties are to be replaced (because of the unpopular grain quality of IR-8 and unsuitability of IR-22) by IR-26. In 1977, 100 tons of IR-26 seed were imported and multiplied. It is hoped that 1,800 tons of seed will be available to plant 15,000 ha. (37,000 acres) in 1978.[7]

[6] Data provided by N. Erus, Chief, Basic Data Unit, Statistics Division, FAO, Rome, January 19, 1976.

[7] Letter from Omar Ali Ameen, Head, Cereal and Legume Crops, Directorate General of Field Crops, Abu Ghraib Farm, Baghdad, December 21, 1977.

AFRICA

Rice traditionally has not been a major crop in Africa, but it is becoming increasingly important, particularly in West Africa. Before the 19th century, the local rices belonged to the African cultivated species, *Oryza glaberrima*. In favored areas, the African rices have been rapidly replaced by *O. sativa* varieties introduced principally from tropical Asia.[1]

The first semi-dwarf types of rices came from Taiwan and IRRI. Technical assistance missions from Taiwan introduced Taichung Native I, I Kong Pao and others in a number of West African nations.[2] IR-8 was imported by the Ivory Coast and Liberia as early as 1967; IR-5 and C4–63 followed in 1968 (and also were imported by Ghana).[3]

The response of these varieties to West African conditions varies considerably. Under controlled irrigation conditions, as well as on some broad flood plains not subject to deep flooding, they have shown considerable potential and are commercially planted. They have not fared as well under other cultural conditions including upland, deeply flooded, and mangrove. They also are susceptible to local strains of diseases—particularly blast (*Pyricularia oryzae*), which is severe where there is water stress. Cultivation practices also differ.[4]

Research to develop varieties suitable to local conditions is underway in numerous country and regional programs. Among the latter, the longest standing effort has been carried out by the French-sponsored Institute de Recherches Agronomiques Tropicales et des Cultures Vivrieres (IRAT) in a number of African nations.[5] The International Institute for Tropical Agriculture (IITA) is a more recent participant, with programs at its headquarters in Nigeria and in several nations.[6] Considerable testing of improved varieties also is being done under the auspices of the West African Rice Development Association (WARDA).

Statistical data on the use of HYV's in African nations, however, are rather limited. The relatively modest amount of information it has been possible to obtain is summarized in the following country notes. A short report from WARDA provided the key recent multicountry reference.[7]

By way of background, it might be noted that among the West African nations, the largest total rice areas are found in (decreasing order) Sierra Leone,

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[1] T.T. Chang, "Rice," in *Evolution of Crop Plants* (N.W. Simmons, ed.), Longman, London, 1976, pp. 98–104. Also see Te-Tzu Chang, "The Origin, Evolution, Cultivation, Dissemination and Diversification of Asian and African Rices," *Euphytica*, 1976 (Vol. 25), pp. 425–441.

[2] R. Chabrolin, "Rice in West Africa," in *Food Crops of the Lowland Tropics* (ed. by C.L.A. Leakey and J.B. Wills), Oxford University Press, 1977, pp. 12, 19, 20.

[3] Based on unpublished data on seed exports from the Philippines (see introduction to Chp. IV).

[4] Chabrolin, *op. cit.*, pp. 12, 20; "The Use of High-Yielding Varieties in Africa," WARDA, January 1977, pp. 2–3; and *Highlights of 1976 Research*, IITA, pp. 115, 118.

[5] Chabrolin, *op. cit.*, p. 12; "The Use of . . .," *op. cit.*, p. 2; R. Chabrolin, "Contribution de l'IRAT al'amélioration des variétés de riz pluvial," *L'Agronomie Tropicale*, Paris, October 1974, pp. 1016–28. Three semi-dwarf varieties were recommended by IRAT as of 1974: IRAT-9 (IN-1 x RT 1021–69), IRAT-11 and 12 (IN-1 x Tunsart). IRAT-9 was developed in Ivory Coast in 1973, IRAT-11 and 12 in Senegal in 1970.

[6] *Highlights of 1976 Research*, *op. cit.*

[7] "The Use of . . .," *op. cit.*, pp. 4–8.

Ivory Coast, Mali, and Liberia.[8] In terms of rice consumption per capita, the leading countries are Sierra Leone, Liberia, Gambia, Senegal, and the Ivory Coast.[9]

Outside the West African region, rice is a major crop on Madagascar (Malagasy Republic), but no information has been found on the use of HYV's.[10]

Benin[11]

All rice production in Benin (formerly Dahomey), except upland rice, is under the control of the Société Nationale d'Irrigation et d'Amagement Hydro-agricoles (SONIAH). The main activities of SONIAH are along the Oueme River and its flood plains. Some 600 ha. (1,500 acres) have been developed with reasonable water control, while water conditions are being improved for another 400 ha. Another 1,100 ha. (2,700 acres), under the control of the Chinese, are scattered over the country. IR-8 was the main variety but is being replaced by IR-442 (IR95–31–4 x Leb Mue Nahng) because of its greater adaptability to the water regime. IR-20 also is grown.

Cameroon[12]

In 1970, several hundred hectares of IR–8 rice were planted in West Cameroon but, due to a variety of problems, largely disappeared. By late 1975, an estimated 400 to 500 ha. (1,000 to 1,240 acres) of IR–20 and IR–24 were being grown in an irrigated rice project at Yagoua. Other varieties grown included Taichung 178 and D114H (origin uncertain). IR–22 was tried but was wiped out by neck blast.

As of 1977, perhaps 1,500 ha. (3,700 acres) of HYV's were being raised. Major locations, beyond the project at Yagoua in the north, include the northwest and Mbo plain in the west. Principal HYV's are IR–20, IR–24, and Jaya; some IR–8 still is planted at Yagoua. Prospects for continued increases in HYV are considered good.

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[8] "Prospects for Intraregional Trade of Rice in West Africa," Food Research Institute, Stanford University (in cooperation with WARDA), September 1977, tables F-2 to F-13 (draft).

[9] "The Use of . . .," *op. cit.*, p. 3.

[10] The Institute de Recherches Agronomiques a Madagascar (IRAM) had, as of 1973, developed some new rice strains, largely from varieties imported from Taiwan (Dept. of State Airgram A-028 from Tananarive, March 9, 1973). But national rice policy since then has not encouraged the adoption of intensive yield-increasing methods of production.

[11] "The Use of . . ., *op. cit.* (hereinafter cited as WARDA), p. 8; letter from William Gamble, Director-General, IITA, January 4, 1978.

[12] Letters from M.H. Ford, Agricultural Advisor, USAID (Area Development Office for Central Africa), American Embassy, Yaounde, Cameroon, November 7, 1975, November 3, 1977, and undated note (December 1977).

Gambia [13]

About 1,800 ha. (4,500 acres) of small, pumped-irrigation schemes have been developed along the River Gambia. One account indicates that the main varieties are Taichung Native 1, I Kong Pao, and XA 228. Another source indicates that IR–22 is the main variety, and that others being increased include ROK–5, I Kong Pao, IR–305, IR–442, and IR–528.

Ghana [14]

The principal HYV rice area is found in the wide, flat lowlands of northern Ghana. C4–63 was introduced from the Philippines in 1969 or 1970, but proved susceptible to blast; it is, however, still grown by a number of small farmers. One metric ton of IR–20 seed was imported during 1971/72. It and IR–5 were introduced between 1972 and 1975, and replaced C4–63 on the larger farms. Nearly 3,000 M.T. of seed of IR–20 and IR–5 were distributed during 1976 for planting on approximately 64,800 ha. (160,000 acres) in the northern region. For all of northern Ghana (including the upper region), WARDA suggests that "it may be safely assumed that . . . not less than 250,000 acres (101,200 ha.) was planted to the HYV's." The HYV category also includes IR–442 (IR 95–31–4 x Leb Mue Nahng); this variety was considered very promising at one point but has proven susceptible to blast. IR–5 also is susceptible. A search for blast-resistant varieties is underway.

Ivory Coast [15]

The Centre de Semence (Center for Seed Multiplication and Improvement) was cooperatively established in 1967 at Dabou by the national government and an agricultural technical mission from Taiwan. From IRRI lines, the Center selected and named seven varieties: CS–1 through CS–7. In 1972, with the assistance of the European Development Fund (FED), the national government established the SODERIZ (Société Pour le Development de la Riziculture) seed company. Seeds of IR5, IR8, and CS–5 (IR506–1–36), CS–6 (IR480–14), Taipei-309, and Chianan-8 were multiplied and distributed: 57 M.T. in 1972 and 94 M.T. in 1973.

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[13] WARDA, *op. cit.*, p. 5; Gamble, *op. cit.*

[14] Letter from Oleen Hess, Food and Agriculture Officer, USAID, American Embassy, Accra, October 17, 1975; WARDA, *op. cit.*, p. 6; Gamble, *op. cit.*; and "Recommended Practices for the Production of Rice," Grains and Legumes Development Board (Kumasi), Technical Bulletin 2, pp. 1, 2 (enclosure to FAS Report GH–6003 from Lagos, Nigeria, February 6, 1976).

[15] M. T. Tzen, "Improvement of Lowland Rice Varieties in Ivory Coast" (in Chinese), *Sci Agr. Soc.*, Taipei, 1975 (excerpted by T. T. Chang, IRRI, letter, March 10, 1976); letter from M. Rossin, Le Director Technique, Société Pour le Developement de la Riziculture (SODERIZ), Abidjan, February 22, 1974; letter from John E. Riesz, Agricultural Attaché, American Embassy, Monrovia, Liberia, April 23, 1974; and WARDA, *op. cit.*, p. 5.

A number of cooperative programs, involving thousands of acres, are underway to improve and expand rice culture. One major effort, financed by FED, is being undertaken in swamp areas in the north; about 70 percent of the area is planted to IR–5 and 30 percent to IR–8. Significant quantities of these two varieties also have been planted in the Yamassukro area. Altogether, perhaps 3,000 ha. (7,400 acres) were planted to high-yielding varieties, including Jaya, in the 1973–74 period. As of 1976, the four main varieties for irrigated conditions were IR–5, IR–8, Jaya, and CS–6.

Liberia [16]

Liberia grows very little paddy rice but has a substantial area of upland rice. The semi-dwarf HYV's do not appear to be widely used, though some IR–5 is grown. Farmers prefer a variety with longer straw. IITA has a cooperative rice improvement program with the central Experiment Station at Suakoko. The program recently produced a new variety, Suakoko 8 (Siam/Malunja[3]), which has good tolerance to iron toxicity (a problem with IR–5 in swamp areas).

Mali [17]

The largest irrigated rice project is that of the Office du Niger, which had about 40,000 ha. (98,800 acres) under rice in 1976. Unfortunately, water control is not adequate for the use of semi-dwarf varieties. These varieties have been used, however, in crosses with local varieties. Two promising varieties have been obtained from a cross of Kading Thang and HK698: Malirat B42 and Malirat DK3. The latter is considered the more promising and should soon be ready for multiplication and distribution to farmers.

Mauritania [18]

As of late 1976, some 1,000 ha. (2,500 acres) were developed for irrigated rice. The two main varieties grown are Tachung Chun Way and I Kong Pao.

Niger [19]

Of some 14,000 ha. (34,600 acres) of rice in Niger, about 2,600 ha. (6,400 acres) were irrigated as of of the end of 1975. IR–22 and some IR–8 are the only

[16] Letters from Riesz, *op. cit.*, April 23, 1974, September 19, 1974; *IITA Annual Report, 1974*, pp. 177–179; letter from Gamble, *op. cit.*; *International Rice Research Newsletter*, IRRI, February 1978, pp. 3, 4.

[17] WARDA, *op. cit.*, p. 6.

[18] *Ibid.*

[19] *Ibid.*, p. 7; *op. cit.*; letter from Norman L. Garner, Acting Project Manager, Niger Cereals Project, USAID, American Embassy, Niamey, March 21, 1978.

varieties grown under controlled irrigation (irrigated perimeters). IR–1529 is being considered as a replacement for IR–22 because of its longer grain and greater resistance to drought. In areas of noncontrolled irrigation (variable perimeters) the main varieties are Sintane Diofor, Nang Kiev, and D52–37; D52–37 is a tall variety which also is raised near the edge of rivers.

Nigeria [20]

IITA has supplied about 2 M.T. of IR–20 seed multiplied from stock brought from IRRI by Dr. J.C. Moomaw in 1970. Some plantings failed because of drought, but others did well. Moomaw estimated that perhaps 500 to 600 ha. (1,200 to 1,500 acres) of the IRRI varieties were raised in 1973. As of 1976, IR–20 still was spreading wherever irrigation was adequate. Local designations for these varieties are: Faro 13 (IR–8), Faro 19 (IR–20), and Faro 23 (IR–5).

IITA is carrying on a rice improvement project with Nigeria. Three varieties from this project currently being grown are TOS–42 (IR 665–79–2), TOS–78 (IR–269–26), and TOS–103 (IR–790–35–5). Another variety of IRRI origin is Faro 22 (IR–627–1–31).

Senegal [21]

HYV rice is grown in three areas of Senegal: along the Senegal River, in the Casamance, and in eastern Senegal. The most important area appears to be along the Senegal River, where full water control is possible on 3,300 ha. HYV's in use include TN–1, I Kong Pao, and Jaya (20 M.T. of Jaya seed were imported from India during the 1974/75 season). As of early 1976, TN–1 reportedly was raised on about 3,000 ha. (7,400 acres). A new variety, IR1561–152, was released recently. The Casamance area includes swamp and upland areas: I Kong Pao and IR–8 are grown on gray soils and in the swamps. I Kong Pao also is grown in eastern Senegal, mainly on gray soils. A new experimental station for research on rice and other irrigated crops has been developed at Fanaye.

Sierra Leone [22]

Seierra Leone has not moved strongly in the direction of semi-dwarf rices. The main constraints are diseases, toxic soil factors, limited irrigated area, and farmer preference for long-duration varieties. Nevertheless, the Nationalist Chinese, before they left in 1972, had a planting of about 60 ha. (150 acres) of

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[20] Letters from J.C. Moomaw, IITA, October 12, December 28, 1973; WARDA, *op. cit.*, p. 8; and Gamble, *op. cit.* (IRRI line numbers noted above have been abbreviated.)

[21] Letter from Robert E. Haresnape. Agricultural Attaché, American Embassy, Monrovia, April 26, 1976; WARDA, *op. cit.*, p. 5.

[22] Moomaw, *op. cit.; IITA Annual Report, 1974*, pp. 177, 179; WARDA, *op. cit.*, pp. 3, 4; Gamble, *op. cit.;* letter from Norman L. Sheldon, Agricultural Development Officer, USAID, Freetown, April 6, 1978.

IR–5 on the Little Scarcies River below Mange; this still was being grown as of 1977. Some BD–2 and IR–20 are raised, but the former must be harvested early or it shatters; the latter "requires regular inputs not readily available." IITA is conducting a cooperative rice improvement program with the Rice Research Institute at Rockupr, where USAID has provided funds for the improvement of facilities. The cooperative program recently has selected a new variety, ADNY 11 (IR 665 x Tetep from Colombia), which may become widely grown under irrigated conditions.

Togo [23]

Only about 300 ha. (740 acres) of rice land exist in Togo. Most of it was established by a team from Taiwan (this group was replaced by a team from the People's Republic of China in 1974). IR–8 was the main variety grown through 1974. The PRC has introduced a variety known as Ainachen. IR–442 also is grown.

Upper Volta [24]

A relatively small area of HYV rice is raised under irrigation in Upper Volta. The principal varieties appear to be C–74 (BPI–74 from the Philippines) and CICA–4. AID is helping sponsor a seed multiplication project which produced 230 tons of C–74 seed in 1977 for sowing in 1978 (the same project also produced other improved seeds including Gambiaka, Sintane, Dourado, and IRAT–10). Research is done by the Centre d'Experimentation du Riz et des Cultures Irrigueés at the Farako-Ba Experiment Station near Bobo-Dioulasso in the southwest part of the country.

Zaire [25]

The first major rice improvement work in Zaire was carried out from 1968 to 1972 by a team of rice specialists from Taiwan. In 1973, the rice development work was taken over by a team from the People's Republic of China. The PRC team is evidently carrying out this program in the town of Bumba in northern Zaire along the Zarian river. By the fall of 1975, four experimental fields had been established with a total area of 42 ha. (104 acres). Three pilot villages and six secondary villages were designated for multiplication purposes. North Koreans are expected to assist with the seed multiplication. Technicians reportedly were working with a combination of Asian, American, and Philippine varieties for crossing with Zarian rice. The PRC contract ends in 1978.

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[23] WARDA, *op. cit.*, p. 7; Gamble, *op. cit.*

[24] WARDA, *op. cit.*, p. 7; letters from Richard C. Meyer, Director, Office of National Projects, USAID, American Embassy, Ouagadougou, January 10, 1978, February 13, 1978.

[25] Foreign Agricultural Service Reports from Kinshasa: ZR–5019, September 26, 1975; ZR–5002, January 30, 1975, p. 4.

LATIN AMERICA

Rice is not of major importance in Latin America, compared with Asia, but is planted over a greater area than in Africa. The major producer, by a very wide margin, is Brazil, followed at some distance (in 1977) by Colombia, Mexico, Peru, Cuba, and Venezuela. About 28 percent of the rice area in Latin America in 1976 was irrigated and 72 percent was upland.[1]

HYV's of rice are raised in most, but not all, of the rice producing nations in Latin America. They generally are found in both irrigated and upland areas in Central America and irrigated areas in South America.. In the long-established rice-growing areas where HYV's have been utilized, they largely have replaced improved varieties.

Research on new varieties has been carried out by the International Center for Tropical Agriculture (CIAT) in Colombia since 1967, utilizing breeding stock from IRRI. CIAT and IRRI initiated an International Rice Testing Program for Latin America in mid-1976; national programs are being provided improved breeding materials for different growing conditions.[2]

The data on area planted to the HYV's in Latin America are not yet historically complete or fully developed. Such data as have been found for 17 countries are summarized here. Seasonal classifications are not entirely consistent among the countries listed.

There is considerable room for expansion of HYV area, particularly as irrigated areas along rivers are developed. The main constraint may be insufficient demand for rice.

Brazil

Most of the rice area in Brazil is nonirrigated upland, but roughly 15 to 20 percent is irrigated. In the past, virtually all of the irrigated land has been in the subtropical zone in the southern portion of the country—in the states of Rio Grande do Sul and Santa Catarina. Recently, irrigated rice has come under increased production in tropical areas in the northern portion of the country. Operations are highly mechanized in both regions.[3]

Official data are not available on the area planted to semi-dwarf varieties in the country as a whole. The only detailed variety estimates are for Rio Grande do Sul. It appears that some semi-dwarfs (CICA–4, IR–8, and IR–665) are raised in upland areas and that these and other varieties (IR–22, TN–1, IR–661, IR–841) are raised in irrigated zones in other states.[4]

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[1] Dennis Johnson, "Upland Rice, An Overlooked Crop of Latin America," Dept. of Geography, University of Houston, April 1978, p. 4 (presented at the annual meeting of the Association of American Geographers, April, 1978).

[2] Letters from Manuel J. Rosero, IRRI Liaison Scientist for Latin America, CIAT, December 21, 1977, February 21, 1978. The program officially was formalized in June 1977.

[3] Dennis Johnson, "Agronomic Aspects of Rice Production in Brazil," Dept. of Geography, University of Houston, October 1977, pp. 12, 55–67 (paper presented at CIAT Rice Workshop, October 3–November 3, 1977).

[4] *Ibid.*, pp. 27, 28, 49, 50.

Estimates prepared by the Instituto Rio Grandense do Arroz (IRGA) indicate that the area planted to CICA–4 totaled 4,500 ha. (11,100 acres) in 1974/75 and 17,000 ha. (42,000 acres) in 1975/76.[5] CICA–4 represented 3.3 percent of the total area planted in the state in 1975/76. Area estimates are not yet available for 1976/77.

A lower proportion of the rice area of Santa Catarina, and in other states is planted to semi-dwarfs. If this proportion is arbitrarily placed at 1.0 percent for Santa Catarina and 0.2 percent for the rest of the country, the area might total 11,000 ha. (27,000 acres) in 1976. This could be conservative; one large irrigation development of 2,150 ha. (5,300 acres) in Pará was planted entirely to semi-dwarfs in 1977.[6]

All told then, the area of semi-dwarfs in Brazil in 1975/76 was probably at least 28,000 ha. (69,000 acres). The area undoubtedly grew in 1976/77. One Latin American rice specialist writing in April 1978 placed the "present" HYV rice area in Rio Grande do Sol and Santa Catarina as at least 100,000 ha. (247,000 acres).[7]

Research on rice in Brazil began in 1937 with the establishment of a rice experiment station about 10 miles from Porto Alegre in Rio Grande do Sul. In 1959, the station—operated by IRGA—released the first varieties in its EEA series. These are planted widely now.[8] As of 1977, the station also was working with some new lines (P–790, P–793, and P–798) which were developed at CIAT in 1975/76; they are derivatives of IR–930 (CICA–4).

The National Rice Center of EMBRAPA, the national agricultural research organization, is testing new cultivars from IRRI and CIAT throughout the country. Experimental yields and blast resistance have been good, but market acceptance is not promising because of consumer preference for moderately thick rather than thin grains.[9]

Colombia[10]

Rice improvement work began in Colombia in 1957. Several improved varieties were released by the Instituto Colombiano Agropecuaria (ICA): Napal, ICA–10, and Tapuripa. In 1967, ICA turned to the development of semi-dwarf varieties and joined forces with the rice program of the newly established International Center for Tropical Agriculture (CIAT).

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[5] *Anuário Estatistico do Arroz,* IRGA, Porto Alegre: Vol. 31, January 1976, p. 68; Vol. 32, January 1978, p. 71 (provided by James Truran, Assistant Agricultural Attaché, American Embassy, Brasilia). In the fifth edition of this bulletin (p. 101), an HYV estimate of perhaps 35,000 ha. (86,500 acres) was reported for 1974/75.

[6] Johnson, *op. cit.*, pp. 63–66 (70 percent IR–22 and 30 percent Ceysuoni from Surinam).

[7] Letter from Manuel J. Rosero, IRRI Liaison Scientist for Latin America, CIAT, April 11, 1978.

[8] *Rice in Rio Grande do Sul,* Instituto Rio Grandense do Arroz (IRGA), Porto Alegre, 1970, unnumbered. Statistics on the area planted to the EEA series are provided in the *Anuario . . ., op. cit.* In addition, IRRI line 930–31–10 was named IRGA–408 in 1975 (*Lavoura Arrozeira,* IRGA, November/December 1975, pp. 32, 33).

[9] Johnson, *op. cit.*, pp. 78–80.

[10] This section is partly based on: Peter R. Jennings, "The Amplification of Agricultural Production," *Scientific American,* September 1976, p. 194; Grant M. Scobie and Rafael Posada T., *The Impact of High-Yielding Rice Varieties in Latin America, With Special Emphasis on Colombia,* CIAT, Series JE–01, April 1977, pp. 13–18; Reed Hertford, Jorge Ardilla, *et al.*, "Productivity of Agricultural Research in Colombia," in *Resource Allocation and Productivity in National and International Agricultural Research* (ed. by T.M. Arndt, D.G. Dalrymple, and V.W. Ruttan), University of Minnesota Press, 1977, pp. 88–95.

In 1966, IR–8 was introduced from IRRI for use in irrigated tropical areas. This was followed by the release of IR–22 and CICA–4 in 1971, CICA–6 in 1974, and CICA–7 and CICA–9 in 1976.[11] All were recommended for irrigated lands. Estimates of the area planted to these varieties follow:[12]

Year	Total HYV area		Proportion of HYV area planted to					
			IR–8	IR–22	CICA–4	CICA–6	Other	Total
	Hectares	*Acres*	*Percent*					
1968	(100)[a]	(200)[a]	100	—	—	—	—	100
1969	(9,300)[a]	(23,000)[a]	100	—	—	—	—	100
1970	(41,000)[a]	(103,500)[a]	100	—	—	—	—	100
1971	(66,600)[a]	(164,600)[a]	76.3	9.1	14.6	—	—	100
1972	125,400	309,700	39.9	21.4	38.7	—	—	100
1973	165,800	409,700	35.3	42.6	22.1	—	—	100
1974	273,000	674,500	39.4	32.8	26.9	0.1	—	100
1975	286,000	706,600	19.8	30.2	36.9	13.1	—	100
1976	260,600	643,800	10.1	27.8	37.2	24.9	—	100
1977	235,000	580,700	7.1	19.3	38.3	20.0	15.3[b]	100

[a] Estimated.
[b] CICA–7, 5.8 percent; CICA–9, 9.1 percent; mixed 0.5 percent.

By 1975, all of the irrigated area had been planted to semi-dwarfs.

The rice blast disease is a constant threat and the hoja blanca virus, presently controlled by varietal resistance, could again become a significant yield restraint.

Costa Rica

Semi-dwarf varieties found early and rapid adoption in Costa Rica. By 1975, about 96.2 percent of the total rice area was planted to HYV's, mostly in nonirrigated areas (very little cropland is irrigated). Yearly estimates of the HYV area are as follows:[13]

[11] The geneology of the CICA varieties is presented graphically in Jennings, *op. cit.*, p. 183 (an earlier version of the chart is found in Scobie and Posada, *op. cit.*, p. 14.). Details on CICA–6 are found in the *CIAT Annual Report, 1974*, pp. 211 and 212. Details on CICA–7 and CICA–9 are provided in the *CIAT Annual Report, 1976*, pp. F10–F11, and in "Nuevas Variedades de Arroz, CICA 7, CICA 9," Fedearroz, Bogota, October 1976, 14 pp.

[12] The sources of the estimates were as follows: (a) 1968 to 1971, Hertford and Ardilla, *op. cit.*, p. 91 (estimates converted from proportion of total area to proportion of HYV area); (b) 1972, office of Dr. Manuel Rosero, ICA; (c) 1973, *Programa Nacional de Arroz, Informe Anual de Progreso 1973*, ICA, pp. 1,3,4; (d) 1974–1976, data provided by Alfred R. Persi, Agricultural Attaché, American Embassy, Bogota, November 23, 1977, February 21, 1978, and April 28, 1978 (based on information provided by Fedearroz); and (e) 1977, letter from Persi, June 6, 1978 (data from Fedearroz and the Ministry of Agriculture).

[13] 1970 to 1975 estimates provided by Grant Scobie, CIAT; 1976 estimates provided by James E. Hawes, Rural Development Officer, US/AID, San Jose, November 11, 1977 (based on information provided by Ing. Alberto Vargas, Sub-Director, Division of Investigation, Ministry of Agriculture, San Jose).

Year	HYV area	
	Hectares	*Acres*
1970	16,000	39,500
1971	22,900	56,600
1972	50,000	123,600
1973	55,500	137,100
1974	64,200	158,600
1975	81,600	201,600
1976	80,200	198,100

The varietal breakdown is not entirely clear. Rather scattered data suggest that as of 1971/72 the HYV area was entirely IR–8. IR–22 and CICA–4 became of increasing importance in 1972/73. By 1973/74, over 90 percent of the HYV area was planted to CICA–4. In 1974/75, the principal HYV was CR–113 (selected from IR–822–81–2 at CIAT). The switch to CR–113 was prompted by the susceptibility of the other varieties to blast.[14]

Dominican Republic

IR–8 rice was introduced in the Dominican Republic in December 1966. Other lines and varieties followed.[15] A variety known as Juma 57 was obtained by crossing IR–8 with Nilo.[16] CICA–4 was renamed Avance 72. One rough early estimate suggested that about 15 percent of the area in 1972/73 (perhaps 10,000 ha. or 25,000 acres) was planted to identified HYV's.[17] A subsequent estimate for 1976 suggests that the total HYV area was about 19,900 ha. (49,200 acres). The main HYV's were Juma 57, Juma 58 (Tono Brea x IR–8), CICA–4, Tanioka (a local selection from IRRI materials), IR–5, and IR–6.[18]

Ecuador

While the HYV's have been raised in Ecuador since the early 1970's, there is some question about their actual area. This is partly a definitional problem. If the HYV's are defined as IR–8 and INIAP–6 (CICA–4), the following data may be derived for the 1971/72 to 1973/74 period:[19]

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[14] Based on: data reported in the previous edition of this report; letter from Vargas to Milton Lau, USAID, San Jose, October 17, 1973; information provided by Peter Jennings, Rockefeller Foundation.

[15] *Comportamiento del IR–8 en la Republica Dominica,* Secretaria de Estado de Agricultra, 1969, 12 pp.

[16] Letter from L. R. Fouchs, Agricultural Attaché, American Embassy, Santo Domingo, October 11, 1973. About 350 ha. (864 acres) of Juma 57 were planted in 1972.

[17] *CIAT Annual Report, 1972,* p. 160.

[18] Letter from Domingo Marte, USAID, Santo Domingo, December 8, 1977 (information provided by Jose Miguel Cordero Mora, Director Dpto., Fomento Arracero, Secretaria de Estado de Agricultura).

[19] Letters from C. Milton Anderson, Agricultural Attaché, American Embassy, Quito, December 1, 1975 and January 14, 1976 (data developed in cooperation with the National Agricultural Research Institute of Ecuador). The figures reported here are somewhat larger than those gathered by CIAT.

Crop year	HYV area		Proportion of HYV area		
			IR–8	INIAP–6	Total
	Hectares	*Acres*		*Percent*	
1971/72	17,500	43,200	76.9	23.1	100
1972/73	24,200	59,800	48.4	51.6	100
1973/74	61,900	153,000	20.4	79.6	100

Similar estimates have not been located for subsequent years. Data were obtained, however, for the total area planted to IR–8 and INIAP varieties by calendar year, during the 1970's:[20]

	Hectares	*Acres*
1970	15,700	38,700
1971	9,900	24,300
1972	15,800	39,000
1973	41,700	102,900
1974	78,400	193,700
1975	98,000	242,100
1976	83,000	205,100
1977*	79,400	196,100

*Preliminary

The problem with this classification is that varieties included under the INIAP category are not known exactly. Those that are known—INIAP–6, INIAP–2 (IR–22), and INIAP–7 (CIAT line 4444)[21]—are HYV's, but there may be others which are not.

El Salvador

As of 1974/75, the rice area of El Salvador appeared to be planted largely to *improved* varieties. While data were available for 11 varieties, none were identified as semi-dwarfs. Some semi-dwarfs (such as CICA–4), however, may have been included in the "other" category, which accounted for 29 percent of the total area. Also, a variety known as Nilo 11, which is a sister selection of IR–22, was named in El Salvador but was not specifically listed. Another semi-dwarf selection (from IR160–27–4) was known as Nilo 9.[22]

While more recent official varietal estimates have not been obtained, the president of the Rice Producers Cooperative estimated that at least 50 percent of

[20] Letter from Joe J. Sconce, AID Affairs Officer, Quito, January 18, 1978.

[21] CIAT line 4444 (a sister line to 4440) was named INIAP–7 in 1976 (*CIAT Annual Report, 1976*, p. F1).

[22] Based on: Foreign Agricultural Service Report ES–4038 from San Salvador, August 1, 1974; letter from James W. Brock, Agricultural Attaché, American Embassy, San Salvador, November 14, 1975; conversation with Peter Jennings, Rockefeller Foundation, New York, January 21, 1976.

the total area was planted to semi-dwarf varieties in 1976/77. A 50-percent figure would have produced an HYV area of nearly 7,000 ha. (17,300 acres). The principal varieties were CICA–4, CICA–6, X–10, Costa Rica 1113, and two new varieties developed in El Salvador, Masol-1 and Masol-4. The Masol varieties have largely replaced the Nilo varieties.[23]

Guatemala[24]

Guatemala has used improved American varieties for some time. The first semi-dwarf HYV's used in the country appear to have been CICA 4 and IR–22. CICA 4 was grown on about 250 ha. (620 acres) in 1974 and on nearly 1,500 ha. (3,700) acres in 1975. Other HYV's raised on another 475 ha. (1,200) acres in 1975 included IR–100, CR–1113, and ICTA–6 (CICA–6).

In 1977, Tikal 2 was introduced. It originated from CIAT line 4422, a sister line of CICA–9, and was named by the Institute de Ciencia y Tecnologia Agricolas (ICTA) in 1976. It is estimated that about 4,000 ha. (10,000 acres) may be planted in 1978 and that in 1979 it will account for over half of the total rice area in the country.

As of early 1978, it was estimated that about half of the rice area in Guatemala was planted to HYV's. Given a total area of about 17,000 ha. (FAS estimates), the total HYV area would be about 8,500 ha. (21,000 acres).

Guyana[25]

A modern rice research station has been established in Guyana as part of an AID loan, and a plant breeder has been trained at IRRI. Materials from IRRI and CIAT have been used to develop varieties suited to local conditions. Several have been developed (including varieties "S" (IR 1055) and "N") but are not in widespread use as yet. Others are under development.

Honduras[26]

High-yielding varieties appear to be fairly widely used in Honduras. Their area increased as follows:

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[23] Letters from James W. Brock, Agricultural Attaché, American Embassy, San Salvador, February 1, 1978, April 3, 1978. The Masol varieties were developed on the farm of Mario Sol out of Nilo varieties.

[24] Letter from Carl D. Coone, Rural Development Officer, USAID, Guatemala City, February 22, 1978 (enclosing letter from W. Ramiro Pazos M., Coordinator, Programa de Arroz, to Astolfo Fumagalli C., Subgerente General, ICTA, February 16, 1978); letter from Manuel J. Rosero, IRRI Liaison Scientist for Latin America, CIAT, February 21, 1978; *CIAT Annual Report, 1976*, p. F1.

[25] Letter from George S. Eason, Rural Development Officer, USAID, Georgetown, November 14, 1977.

[26] Letters from James O. Bleidner, Food and Agricultural Development Officer, USAID, American Embassy, Tegucigalpa, December 5, 1975, February 6, 1978; *CIAT Annual Report, 1972*, p. 160.

Year	HYV area		Principal varieties
	Hectares	*Acres*	
1973	2,500	6,200	Mainly IR–8, some CICA–4
1975	6,300	15,600	CICA–4
1976	6,000	14,800	CICA–6

The 1976 HYV area represented about 38 percent of total rice area.

Mexico

Semi-dwarf rices occupy a significant area in Mexico. Total estimated HYV area is as follows:[27]

Crop/calendar year	HYV area		Proportion of HYV area					
			Sinaloa A–68	Naval-oto A–71	Bamoa A–75	Macus.* A–75	Others	Total
	Hectares	*Acres*	*Percent*					
1971/72	100,000	247,100	60.0	0.5	—	—	39.5[a]	100
1972/73	95,000	234,700	63.2	5.2	—	—	31.6[a]	100
1973/74	114,000	281,700	54.8	30.7	—	—	14.5[a]	100
1974	108,700	268,500	34.3	44.0	—	—	21.3[b]	100
1975	174,100	430,300	11.9	57.5	—	—	32.2[c]	100
1976	133,500	329,900	13.5	44.9	12.0	6.4	23.2[d]	100
1977	151,000	373,100	11.3	26.5	19.9	13.2	29.1[e]	100

* Macuspana.
[a] IR–8.
[b] CICA–4, Joachin A–74, Piedras Negras.
[c] CICA–4; Juchitan A–74, Joachin A–74, Piedras Negras.
[d] Juchitan A–74, CICA–4, CICA–6, Joachin A–74, Piedras Negras.
[e] CICA–6, CICA–4, Joachin A–74, Juchitan A–74, Piedras Negras.

(Note: varieties listed in decreasing order of area.)

[27] The sources of the data are as follows: 1971/72 to 1973/74, letter from Richard A. Smith, Agricultural Attaché, American Embassy, Mexico City, January 14, 1974 (based on information provided by the Instituto Nacional de Investigaciones Agricolas, INIA); 1974–75, tables forwarded by Richard Welton, Agricultural Attaché, American Embassy, Mexico City, October 29, 1975 (obtained from Mexican Dept. of Agriculture); 1976–1977, letter from Dr. Eduardo Alvarez Luna, Director General, INIA, Mexico City, February 9, 1978.

The parentage of these varieties is provided in table 3. Most of the HYV area is irrigated, although several of the HYV's are grown to some extent under rainfed conditions (Sinaloa A–68, Navaloto A–71, CICA–4, CICA–6) and one is raised almost wholly in rainfed areas (Macuspana A–75).

Nicaragua[28]

A high proportion of the rice area, 89 percent as of 1976/77, is planted to HYV's.

Crop year	HYV area		Proportion of HYV area					
			IR–20	IR–22	IR–100	CICA–4	Other	Total
	Hectares	*Acres*			*Percent*			
1974/75	20,700	51,200	37.8	—	34.1	25.0	3.0[a]	100
1976/77	18,700	46,300[c]	—	21.6	64.9	2.7	3.6[b]	100

[a] CR–1113 (a selection of IR–822 produced at CIAT).
[b] Includes: CR–1113, 7.2 percent; CICA–6, 1.8 percent; and Linea 9 (from CIAT),1.8 percent.
[c] Of the total HYV area in 1976/77, about 85 percent was flooded and 15 percent was dryland.

Panama

The first detailed data obtained on the use of HYV'S in Panama are for 1976/77. They indicate a total HYV area of 9,900 ha. (24,500 acres), broken down as follows: CICA-6, 96.6 percent; IR-8, 2.1 percent; and CICA-4, 1.3 percent.[29] A previous estimate for 1974 suggested a total area of CICA-6 and CICA-4 of about 5,600 ha. (12,600 acres).[30]

Paraguay[31]

CICA-4 and CICA-6 were the third most important variety group in Paraguay in 1976. They were planted on roughly 5,200 ha. (13,000 acres), about 25 percent of the irrigated rice area of 21,000 ha.

[28] Based on: letter from Armando J. Gonzalez, Agronomist, USAID, American Embassy, Managua, November 4, 1975; letters from Richard L. Hughes, Rural Development officer, USAID, Managua, November 23, 1977, December 27, 1977 (data obtained from the Technical Department of the National Bank of Nicaragua).

[29] Letter from Raymond A. White, Jr., Agriculture Advisor, USAID, Balboa, October 31, 1977 (based on data provided in the annual report of the Empesa Nacional de Semillas).

[30] Letter from Grant Scobie, CIAT, March 11, 1976.

[31] Wolfgang Jetter, "La Produccion de Arroz en la Republica del Paraguay," CIAT Rice Workshop, October 31—November 3, 1977, unnumbered (provided by Dennis Johnson).

Peru

The HYV area in Peru is relatively large and has grown substantially through the early 1970's.[32]

Crop year	HYV area		Proportion of HYV area					
			IR–8	Naylamp[a]	Chancay[b]	Huallaga[c]	Inti	Total
	Hectares	*Acres*	*Percent*					
1971/72	25,500	65,400	100	—	—	—	—	100
1972/73	38,300	94,600	81.2	13.6	2.6	2.6	—	100
1973/74	36,700	90,700	40.6	54.0	2.7	2.7	—	100
1974/75	62,400	154,000	21.5	71.5	3.5	3.5	—	100
1975/76	70,300	173,700	14.2	71.1	5.7	0.4	8.5	100
1976/77	71,300	176,200	9.8	63.1	5.6	0.4	21.0	100

[a] IR930–2–6.
[b] IR930–31–10.
[c] IR442–2–50.

Over the past 2 years, the major expansion has been in the new variety, Inti. It was developed in the Rice National Program in the Department of Lambayeque. It "comes from IR-8 and F-5 (Fortuna and Minagra)." Leading characteristics are: low height (100 cms.), high yield, good cooking quality, growing period of 156–184 days, and medium resistance to the disease transmitted by the insect *Sogatodes oryzicota*.[33]

Surinam[34]

Essentially all of the irrigated rice area of about 30,000 ha. (74,000 acres) in Surinam appears to be planted to locally developed semi-dwarf varieties of rice. The five main varieties are: Camponi, Ceysuoni, Diwani, Siwini, and Pisari. They are characterized by extra-long grain of good milling quality; a major part of the production is for export.

[32] 1971/72 estimate derived from *CIAT Annual Report, 1972*, p. 160. 1972/73 to 1974/75 estimates provided by Julio A. Castilla, Agricultural Economist, Office of Agricultural Attaché, American Embassy, Lima, November 3, 1975 (data supplied by the Ministry of Food). 1975/76 and 1976/77 estimates provided by Richard L. Barnes, Agricultural Attaché, American Embassy, Lima, November 21, 1977 (estimates supplied by Ing. Cesar Mendez, Ministry of Food).

[33] Letter from Barnes, *op. cit.*, December 20 (information provided by Ing. Mendez).

[34] Hector Weeraratne, "Rice Production in Guyana and Surinam," CIAT Rice Workshop, October 31–November 3, 1977, pp. 2, 6 (provided by Dennis Johnson). Letter from Weeraratne, CIAT, May 3, 1978.

Venezuela

The HYV's were planted first on significant areas (30,000 to 40,000 ha. or 74,000 to 99,000 acres) of IR-22 and CICA-4 in Venezuela in 1973.[35] Since then, the estimated area has continued to expand.[36]

Crop year	HYV area		Proportion of HYV area[a]			
			IR–22	CICA–4	CICA–6	Total
	Hectares	*Acres*	*Percent*			
1974/75[b]	104,000	257,000	25.0	62.5	12.5	100
1975/76	120,000	296,500	25.0	50.0	25.0	100
1976/77	141,700	350,000	17.7	64.7	17.7	100

[a] Excludes Llanero 501b, a locally developed variety which is used by smaller producers employing less intensive cultural practices. Perhaps 26,000 ha. (64,200 acres) were planted in 1974/75, 30,000 ha. (74,100 acres) in 1975/76, and 33,400 ha. (82,400 acres) in 1976/77.

[b] 2,500 M.T. of seed were imported from Colombia in 1975, probably CICA–4 and CICA–6.

Cuba

The semi-dwarf HYV's of rice got off to an early start in Cuba. One account suggests that Cuba originally obtained 1 kg. of IR-8 seed from Mexico and did the multiplication themselves.[37] A Cuban newspaper stated in December 1968 that the seed was obtained only after much difficulty.[38] Two Cuban officials visited IRRI in March 1969 and obtained small seed samples of 26 experimental lines.[39] Production of certified seed was scheduled to begin during the winter of 1970/71.

As of the early 1970's, IR-8 rice was planted rather widely in Cuba. Of the area planted in the "spring campaign" as of late May 1970, 91 percent or about 94,700 ha. (234,000 acres) reportedly was IR-8.[40] Sinaloa A68, an IRRI selection from Mexico, also was grown.

The subsequent status of HYV's in Cuba is not known. However, in July 1977, Dr. Peter Jennings of the Rockefeller Foundation and formerly a rice breeder with CIAT and IRRI, visited with Cuban rice scientists as part of a CIAT team.[41] He estimated that essentially all of the rice area of 100,000 to 110,000 ha. (247,000 to 272,000 acres) is planted to HYV's (excluding area planted to seed and not harvested). Of this, about 50 percent was Sinaloa (Sinaloa A 78, an IRRI selection from Mexico) and the other 50 percent was divided between CICA-4 and Naylamp (from Peru via CIAT).[42]

[35] Letter from Douglas M. Crawford, Agricultural Attaché, American Embassy, Caracas, November 6, 1973.

[36] Letters from: Robert M. McConnell, Agricultural Attaché, American Embassy, Caracas, October 17, 1975 (estimates provided by Dr. Martinez Bello, Director, Seed Experiment Station, Ministry of Agriculture, Marcay); Franklin D. Lee, Assistant Agricultural Attaché, American Embassy, Caracas, November 21, 1977 (data provided by Dr. Bello).

[37] Letter from D. S. Athwal, Assistant Director, IRRI, May 21, 1971 (based on comments by Dr. R. F. Chandler).

[38] Rene Camacho Albert, "Rice Plan, Self Sufficiency in 1971 in Oriente," *Granma* (Havana, in Spanish), December 21, 1968, p. 5.

[39] Athwal, *op. cit.*

[40] "The Spring Campaign Reaches 7,663 Caballerias of Rice," *Granma* (Havana, in Spanish), June 1, 1970.

[41] "The International Centers: Reaching Out to Cuba," *RF Illustrated*, September 1977.

[42] Letter from Peter Jennings, Rockefeller Foundation, November 2, 1977.

V. SUMMARY OF ESTIMATED AREA DATA

This chapter summarizes, by region, the high-yielding variety data presented for individual developing nations in the previous two chapters. It also indicates the approximate proportions the HYV's represent of total wheat and rice area in these regions.

These are difficult tasks that lack precision. The reasons for this have been outlined in Chapter I and touched upon in Chapters III and IV. Still, it might be well to briefly review the reasons why the figures should be treated with a considerable degree of caution. Partly as a result of these matters, the form of the summary in this edition differs from previous editions.

A NOTE OF CAUTION

The individual country data which are summarized here, and the regional totals themselves, are labeled estimates for good reason. They cannot be considered very precise because of problems in both definition and in reporting.

High-yielding varieties are defined here as being of shorter than normal growth habit (usually semi-dwarf). They have the potential for higher than normal yields. Most originated, or had ancestors which originated, at CIMMYT, IRRI, or CIAT. Many have been developed further in country programs. Most of the semi-dwarfs carry the same dwarfing gene, which is usually recessive. The effect of these genes on height, therefore, depends on the particular cross. Moreover, the early Mexican varieties were of normal height. Thus, it is sometimes difficult to know whether some of the new varieties developed in country programs are shorter than normal, and if so, where to draw the line.

Even where this information is available, it may not be reflected in the national crop reporting system. Some nations have, as might be expected, rather rudimentary statistical reporting systems. Sometimes, there is considerable doubt about the total wheat or rice area, and the only information about HYV's may relate to seed production. Where HYV area estimates are available, they may represent overreporting or underreporting. The HYV's may not be defined the same way as in this report; improved varieties of normal height may not be distinguished from semi-dwarfs. And there may be other difficulties—such as questions of consistency in reporting from year to year.

The problems mount further when one attempts to add up such data. Gaps in reporting and differences in reporting periods become a special difficulty. The situation varies somewhat by area, with the Asian data being relatively good (except for rice in Bangladesh; see Appendix C) and the greatest problems

arising in the Near East and Africa. Particular problems will be noted in the course of discussion in the next two sections.

Partly as a result of problems with the Near East, the summary presented in this edition differs from previous editions and is not fully comparable. Relatively less detailed coverage is given to Asia and the Near East, and relatively more is said about Africa and Latin America.

HYV AREA: REGIONAL AND TOTAL

In this section, the HYV areas for each country listed in chapters III and IV are summarized for each of the four LDC regions, and then the regional data are totaled. The LDC total is presented for the first time.

The primary focus is on the 1976/77 crop year. Relatively complete time series data for the 1965/66 to 1976/77 crop years are available only for Asia. Even in the case of 1976/77, complete crop-year data are not available for every country and have been supplemented by calendar-year estimates for 1976 or 1977. Where gaps still persisted, data for an earlier period, and guesses, have been used. The process is not a very precise one—but at least the steps and assumptions are spelled out.

The regional summaries are not strictly comparable with those reported in earlier editions; some countries have been added and some others have been dropped (most notably South Vietnam and Laos). As before, the totals do not include Communist nations, Taiwan, Israel, or the Republic of South Africa.

Trends in individual countries, while of interest, are not discussed, except for a few major countries in Asia. The principal reasons are twofold: the large number of countries involved and the paucity of complete time series data. Suffice it to say that while the general trend is up, there are several exceptions, especially in rainfed wheat areas. The area planted in a given country in a given year also may be influenced by a number of factors, including: other environmental conditions, seed supplies, insect and disease problems, government price policies, and market conditions.

It may be of background value to note the relative importance of each of the regions in terms of overall (traditional and HYV) wheat and rice area. This breakdown may be summarized as follows for non-Communist LDC's:[1]

Region	Wheat		Rice	
	1976	1977	1976	1977
	Percent			
Asia	40.9	44.0	86.5	86.8
Near East	38.9	40.2	1.2	1.2
Africa	1.5	1.6	4.6	4.5
Latin America	18.7	14.2	7.7	7.5
Total	100	100	100	100

[1] Derived from "Reference Tables on Area—Yield—Production of All Grains," USDA, Foreign Agricultural Circular, FG19–77, December 20, 1977, pp. 5, 6, 17, 18. Harvested area.

Clearly, Asia and the Near East are the major wheat areas, while Asia dominates the total rice area. Latin America ranks third in wheat and second in rice. Africa is fourth in wheat and third in rice.

Asia (South and East)

A relatively complete series of HYV data are available for Asia—both in terms of current statistics and a time series for the 12-year period 1965/66 to 1976/77. The number of countries included is rather limited in the case of wheat (4), but more extended in the case of rice (11).

Totals for 1976/77 may be derived as follows for wheat and rice:

Country		Period	Area
			Hectares
Wheat:			
	Bangladesh	1976/77	116,600
	India	1976/77	14,696,000
	Nepal	1976/77	254,200
	Pakistan	1976/77	4,605,500
	Total		19,672,300 (48,610,300 acres)
Rice:			
	Bangladesh	1976/77	1,329,800
	Burma	1976/77	349,000
	India	1976/77	13,731,000
	Indonesia	1976/77	3,428,900
	Korea(S)	1976/77	533,000
	Malaysia(W)	1975/76	222,300
	Nepal	1976/77	220,300
	Pakistan	1976/77	677,900
	Philippines	1976/77	2,416,700
	Sri Lanka	1975/76	331,000
	Thailand	1976/77	960,000
	Total		24,199,900 (59,798,000 acres)

India clearly dominated both totals, representing 75 percent of the regional HYV wheat area and 57 percent of the regional HYV rice area. Pakistan was second in terms of wheat, with 23 percent of the total. Indonesia was second in rice, with 14 percent of the total, followed by the Philippines, with 10 percent. The HYV rice area in Bangladesh has been overreported in recent years (see Appendix C).

Total figures for the 12-year period 1965/66 to 1976/77 were built up in the same way for wheat and rice. These totals are summarized in table 34 and figure 4. The HYV areas of wheat and rice expanded in approximately a straight-line manner—although the area of rice has expanded somewhat more rapidly than the wheat area since 1970/71.[2] It is questionable how long these rates of increase will continue in the future, particularly in countries where grain supplies are becoming adequate. Indian HYV wheat areas are projected to increase only slightly in 1977/78 (table 7) and the Philippine HYV area is forecast to grow only 16 percent during the next 5 years.[3]

Table 34—Estimated Total Area Planted to High-Yielding Varieties of Wheat and Rice in Asia (East and South)[1]

Crop year	Wheat[2]	Rice[3]	Total
		Hectares	
1965/66	9,300	49,400	58,700
1966/67	648,700	1,034,000	1,682,700
1967/68	3,913,900	2,651,800	6,565,700
1968/69	7,242,600	4,665,500	11,908,100
1969/70	7,771,000	7,558,300	15,329,300
1970/71	9,782,500	9,416,500	19,199,000
1971/72	11,275,200	12,348,900	23,624,100
1972/73	13,573,950	14,854,900	28,428,850
1973/74	14,619,700	18,755,400	33,375,100
1974/75	15,218,700	20,323,800	35,542,500
1975/76	17,809,800	21,957,300	39,667,100
1976/77	19,672,300	24,199,900 [4]	43,872,200
		Acres	
1965/66	22,900	122,100	145,000
1966/67	1,602,900	2,555,000	4,157,900
1967/68	9,671,200	6,552,600	16,223,800
1968/69	17,896,500	11,528,500	29,425,000
1969/70	19,202,300	18,676,600	37,878,900
1970/71	24,172,500	23,268,200	47,440,700
1971/72	27,860,950	30,514,100	58,375,050
1972/73	33,541,000	36,558,200	70,099,200
1973/74	36,125,300	46,344,600	82,469,900
1974/75	37,605,400	50,220,100	87,825,500
1975/76	44,008,000	54,009,400	98,017,400
1976/77	48,610,300	59,798,000 [4]	108,408,300

[1] Excludes Communist Asia and Taiwan.
[2] Bangladesh, India, Nepal, Pakistan.
[3] Bangladesh,. Burma, India, Indonesia, Korea (South), Malaysia (West), Nepal, Pakistan, Philippines, Sri, Lanka, Thailand.
[4] Includes Malaysia and Sri Lanka at 1975/76 levels.

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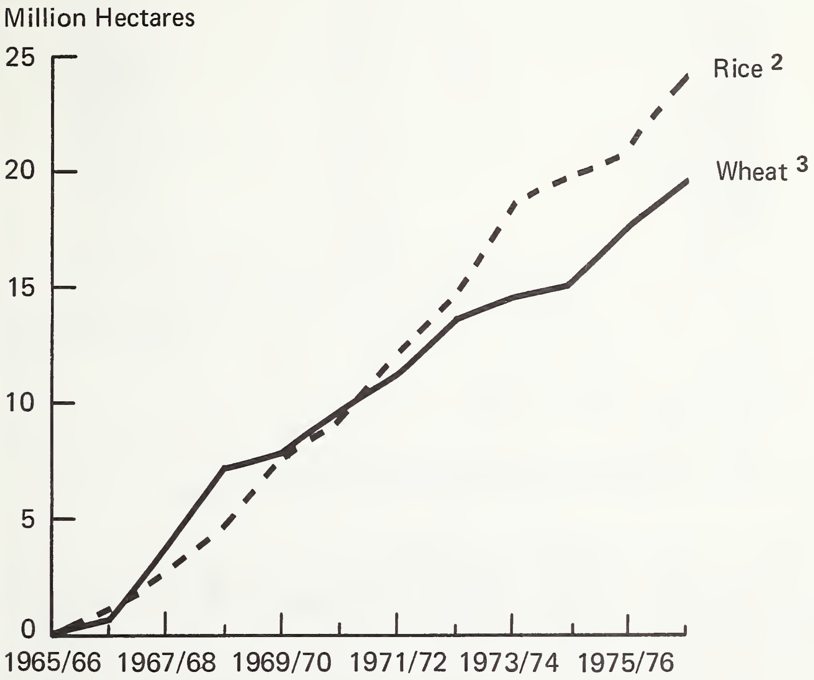
[2] In evaluating the rice totals, however, it should be realized that not every country was included for the full dozen years; only India and Malaysia were included in 1965/66; Korea was the last to be added in 1971/72. (The precise year of entry is given in the individual country tables provided earlier.) Thus, the increase in rice area through 1970/71 was brought about partly by the inclusion of additional countries.

[3] Stuart E. Proctor, Jr., "Philippines: From Rice Importer to Exporter," *Foreign Agriculture*, April 24, 1978, p. 4.

Figure 4—Estimated Area Planted to High-Yielding Varieties of Wheat and Rice in Asia (East and South)[1]



[1]*Excludes Communist Asia and Taiwan.* [2]*Bangladesh, Burma, India, Indonesia, Korea (South), Malaysia (West), Nepal, Pakistan, Philippines, Sri Lanka, Thailand.* [3]*Bangladesh, India, Nepal, Pakistan.*

Near East (West Asia and North Africa)

HYV wheat is grown in a number of countries in the region: HYV rice in only a few. In either case, statistics are difficult to gather for most of the countries.

WHEAT.—HYV wheat is raised in at least a dozen nations in the region. The most recent country estimates may be summarized as follows:

Country	Period	Area
		Hectares
Afghanistan	1976/77	770,000[a]
Algeria	1976/77	300,000[b]
Cyprus	1977	29,000
Egypt	1976/77	125,500
Iran	1975/76	140,000
Iraq	1974/75	750,000
Lebanon	1976/77	25,000
Morocco	1972/73	300,000[c]
Saudi Arabia	1976/77	13,500
Syria	1976/77	362,800
Tunisia	1976/77	228,400
Turkey	1976/77	1,300,000[d]
Total		4,344,200 (10,734,500 acres)

[a] Involves locally improved varieties.
[b] Rough estimate.
[c] Slight rounding up of 1972/73 estimate.
[d] Mexican and Italian varieties; excludes Bezostaya I (see table 20, fn. 8).

The total does not include small HYV areas in Jordan, Oman, and Yemen. Nor does it include Libya. Israel also is excluded. On the other hand, the Afghanistan figure includes local improved varieties which might not qualify as HYV's. It is not known how these factors would balance off. In this case, it has been decided to round the total up to 4.4 million ha. (10.87 million acres) for subsequent tabulations.

While the overall HYV area trend probably has been up in the region, the individual country pattern is more subject to variation than in other regions. This is because a relatively large proportion of the wheat in some countries is raised under rainfed conditions; variations in rainfall can lead to significant variations in the wheat area from year to year. Also, seed supplies have been inadequate in some countries. Government price policies and market conditions have limited the HYV area in other areas.

RICE.—The HYV rice area seems to be confined to three countries: Egypt, Iran and Iraq. A rough estimate of the HYV area in these three nations in 1976/77 would be about 40,000 ha. (98,800 acres).

Africa (excl. North Africa)

The HYV wheat area in Africa is concentrated in a relatively few countries, principally in east Africa; HYV rice production is more widely spread and is found particularly in west Africa. In either case, the HYV area, while only vaguely known, is quite small.

WHEAT.—HYV wheat is known to be raised in only 6 countries, and estimates are available for only 4, as follows:

Country	Period	Area
		Hectares
Kenya	1977	23,300
Nigeria	1974/75	10,000
Rhodesia	1977	15,700
Sudan	1976/77	150,500
Total		199,500 (493,000 acres)

The Rhodesian figure is a minimum; other semi-dwarfs are known to be grown, but their area is uncertain. The semi-dwarf area in Ethiopia also is not known but is some fraction of 150,000 ha. (371,000 acres). HYV's also are grown in Tanzania. As a result, it might be reasonable to suggest a regional total of about 225,000 ha. (556,000 acres) of semi-dwarf HYV's. In addition, a substantial area of other (nonsemi-dwarf) varieties of Mexican extraction were raised in Ethiopia, Kenya, and Tanzania.

The Republic of South Africa, excluded from this total, had a HYV area of 865,700 ha. (2.14 million acres) in 1977.

RICE.—Although this report commented on the use of HYV rice in some 15 countries, area estimates were quite scattered and uncertain. The one relatively firm estimate was also by far the largest: about 101,000 ha. (250,000 acres) in Ghana in 1977. Estimates for nine other countries range from a hundred to a few thousand hectares (the largest areas being in Senegal, Niger, and Cameroon) and very roughly totaled about 11,400 ha. (28,000 acres). Adding these countries together, and including a pure guess of 2,600 ha. (6,400 acres) for unreported areas in these and other countries, brings the total for Africa up to about 115,000 ha. (284,200 acres).

Latin America

The area of HYV's is significant for both wheat and rice. The HYV wheat area, however, is concentrated in three countries, while the HYV rice area is more widely dispersed.

WHEAT.—The HYV wheat area is found principally in Argentina, Mexico, and Brazil. Argentina is easily the leader, but the actual HYV area is unknown. The rather rough estimates available of the proportion of total area planted to HYV's in Argentina vary rather widely; for 1976/77, they indicate a range of 1.93 to 3.85 million hectares, with a midpoint of about 2.9 million ha. (7.15 million acres). If the latter figure is used, the country tabulation might be as follows:

Country	Period	Area
		Hectares
Argentina	1976/77	2,900,000
Brazil	1977	650,000
Chile	1976/77	193,000
Guatemala	1977	35,000
Mexico	1976	785,000
Peru	1977	1,000
Total		4,564,000 (11,278,000 acres)

Aside from the overwhelming uncertainty about Argentina, the figure could be considered either too high or too low. It might be too high in that the total wheat area in Mexico in 1977 dropped off by nearly 20 percent and presumably the HYV area would have dropped also. It might be considered too low because it does not include roughly 650,000 ha. (1.6 million acres) of short varieties in Brazil in 1974/75, which could well be included in a high-yielding category. Also, small areas of HYV's in Colombia, Ecuador, Paraguay, and Uruguay are not included. Dropping the Mexican figure by 20 percent and including the short varieties in Brazil[4] would raise the total to about 5.06 million ha. (12.5 million acres). A very modest allowance for other nations might bring the total to 5.1 million ha. (12.6 million acres).

Varieties of Mexican extraction of normal height are not included in either total.

Rice.—HYV rice production is distributed more evenly than HYV wheat production. And the extent and quality of the reporting appears to be relatively good. On the other hand, the use of different reporting periods (and the lack of 1977 data in some countries where a calendar year is utilized) make the preparation of a regional total somewhat difficult. Also, no national varietal data are available for Brazil: the figure reported here is an unofficial estimate and probably conservative.

Nevertheless, a rough total may be compiled as follows:

Country	Period	Area
		Hectares
Brazil	1975/76	28,000
Colombia	1976	260,600
Costa Rica	1976	80,200
Dominican Republic	1976	19,900
Ecuador	1977	79,400
El Salvador	1976/77	7,000

[4] The problem with doing this is that the data for the short varieties apply to 1974/75; it is not known how their area has changed since then.

Guatemala	1977	8,500
Honduras	1976	6,000
Mexico	1977	151,000
Nicaragua	1976/77	18,700
Panama	1976/77	9,900
Paraguay	1976	5,200
Peru	1976/77	71,300
Surinam	1976	30,000
Venezuela	1976/77	141,700
Total		917,400 (2,266,900 acres)

Since Brazil accounts for most of the total rice area in Latin America, a small proportional increase could have a significant effect on the HYV total for Latin America. For summary purposes, the total is rounded up slightly to 920,000 ha. (2.27 million acres). The inclusion of Cuba would add another 100,000 to 110,000 ha. (247,000 to 272,000 acres).

In comparison, rough tabulations presented in previous reports suggest that the HYV rice area (excluding Cuba) was about 770,000 ha. (1.9 million acres) in 1974/75 and about 430,000 ha. (1.06 million acres) in 1972/73.

Total of Four Regions

While it is difficult to come up with very reliable totals for wheat or rice in some of the regions, once postulated they can easily be compiled and added up. This is done for the 1976/77 period in table 35. The totals exclude, as noted earlier, HYV areas in Communist LDC's, Israel, South Africa, and Taiwan.

It will be seen that the total LDC HYV wheat and rice area in 1976/77 was about 54.7 million hectares (135.1 million acres). Of this total, about 53.8 percent was wheat and 46.2 percent was rice. Over 80 percent (80.2) of the total wheat and rice area was in Asia, followed by Latin America with 11.0 percent, the Near East with 8.1 percent, and Africa with only about 0.6 percent. Asia represented about 67 percent of the wheat area and nearly 96 percent of the rice area. India alone had 50 percent of the total LDC HYV wheat area and nearly 55 percent of the total LDC HYV rice area.

In comparison, the comparable total HYV wheat and rice area in 1974/75 was about 43.0 million hectares (106 million acres). The wheat area: (21.9 million ha.) was slightly larger than the rice area (21.1 million ha.). Thus, the area expansion between 1974/75 and 1975/77 appears to have been considerably larger for wheat (+6.9 million ha.) than for rice (+3.5 million ha.).

Table 35—Estimated Area of High-Yielding Varieties of Wheat and Rice in Less Developed Nations, 1976/77[1]

Region	Wheat	Rice	Total
		Hectares	
Asia	19,672,300	24,199,900	43,872,200
Near East[2]	4,400,000	40,000	4,440,000
Africa[2]	225,000	115,000	340,000
Latin America	5,100,000[3]	920,000	6,020,000
Total	29,397,300	25,274,900	54,672,200
		Acres	
Asia	48,610,300	59,798,000	108,408,300
Near East[2]	10,872,400	98,800	10,971,200
Africa[2]	556,000	284,200	840,200
Latin America	12,602,100[3]	2,273,300	14,875,400
Total	72,640,800	62,454,300	135,095,100

[1] Excluding Communist nations, Taiwan, Israel, and South Africa.

[2] Very rough estimate of area.

[3] Includes a large and very rough estimate for Argentina and short varieties in Brazil (1974/75).

HYV AREA AS A PROPORTION OF TOTAL AREA

Interpretation and evaluation of the HYV area statistics can be facilitated by comparing them against the total wheat and rice areas involved. In this section, the HYV wheat and rice areas are expressed as a proportion of total area for: (1) the four LDC regional totals for 1976/77, and (2) for Asia from 1965/66 to 1976/77. Some general comments are provided on likely future rates of adoption.

The Statistics

To do a proper job of calculating the HYV area as a proportion of total area, one should draw both sets of figures from the same source. The complete tabulation of total area figures, however, was beyond the scope of this study and a shortcut was utilized: total area data were compiled from statistics collected and reported by the Foreign Agricultural Service of the U.S.

Department of Agriculture. The process may have entailed some errors, due in part to varying seasonal definitions, but the overall outcome should not be far off.[5]

REGIONAL TOTALS.—The HYV proportions for wheat and rice in 1976/77 are summarized for each of the four LDC regions, and for the LDC world as a whole in table 36. The total HYV wheat and rice area represented slightly over one-third (34.5 percent) of the total wheat and rice area in the four regions. The proportion for wheat (44.2 percent) was considerably higher than for rice (27.5 percent).

Table 36—Estimated Area of High-Yielding Varieties of Wheat and Rice as a Proportion of Total Area Planted to These Crops, Less Developed Nations, 1976/77[1]

Region	Wheat	Rice	Total
		Percent	
Asia	72.4	30.4	41.1
Near East[2]	17.0	3.6	16.5
Africa[2]	22.5	2.7	6.5
Latin America	41.0[3]	13.0	30.8
Total	44.2	27.5	34.5

[1] Excluding Communist nations, Taiwan, Israel, and South Africa.
[2] Very rough estimate of HYV area.
[3] Includes large and very rough estimate for Argentina, and short varieties in Brazil (1974/75).

When total wheat and rice area is considered by region, Asia had the highest HYV proportion (41.1 percent), followed relatively closely by Latin America (30.8 percent), and at a considerable distance by the Near East (roughly 16.5 percent) and Africa (roughly 6.5 percent).

The regional HYV wheat proportions were particularly high in Asia (72.4 percent), fairly high in Latin America (roughly 41 percent), low in Africa (roughly 22.5 percent), and lowest in the Near East (roughly 17 percent).

The regional HYV rice proportions were highest in Asia (30.4 percent), lower

[5] The regional totals are calculated from "Reference Tables . . .," *op. cit.*, pp. 5–6, 17–18. While the FAS data appear to be reported on a calendar year basis, they actually apply to the following crop year. Thus, 1976 production data include all harvests occurring within the 1976/77 crop year (July to June for most countries; May to April in India and North Africa) (*Ibid.*, p. 2). The 1976 data, therefore, were used as the basis for the 1976/77 regional calculations reported here. The data refer to harvested area.

The Asia country proportions were obtained as follows: The proportions for 1965/66 to 1972/73 were (except for wheat in Bangladesh) taken from those presented in the fifth edition of this report (pp. 114, 115). The proportions for 1973/74 to 1976/77 (and wheat in Bangladesh from 1971/72 to 1976/77) were calculated from total area data reported in unpublished FAS computer printouts dated 1/16/78 (wheat) and 1/30/78 (rice); these are more recent statistics than in "Reference Tables" and cover a longer period (similar rice information subsequently was published as "Reference Tables on Rice Supply Utilization for Individual Countries," Foreign Agricultural Circular FG–4–78, March 1978, 113 pp.). The total wheat area in Nepal in 1973/74 and 1974/75 was taken from data provided by USAID, Kathmandu.

in Latin America (13.0 percent), and relatively low in the Near East (roughly 3.6 percent) and in Africa (roughly 2.7 percent).

If there is a surprise in these figures, it may be that some are higher than may be generally recognized—particularly the wheat proportion in Latin America (though there is a measurement problem referred to in the footnote to the table). The HYV wheat area in Asia is now over two-thirds of the total area.

Asia Country Breakdown.—The HYV proportions for the 12 crop years 1965/66 to 1976/77 are presented for wheat in 4 nations and rice in 11 nations in table 37. These percentages reflect rate of adoption.

As of 1976/77, several nations had HYV proportions over 50 percent:

—Wheat: Pakistan (75.4), Nepal (73.0), and India (71.8).

—Rice: Philippines (68.1), Sri Lanka (63.0; 1975/76).

Five other countries had a third or more of their rice area planted to HYV's in 1976/77: Korea (43.9 percent), Indonesia (41.0 percent), Pakistan (39.8 percent), Malaysia (37.4 percent; 1975/76), and India (35.6 percent).

There is some question as to how much higher the wheat area might climb in the above countries in the future; the rice proportion has more room for further growth. As noted earlier, the wheat proportion in India and the rice proportion in the Philippines are likely to grow only slightly. The HYV wheat proportion in Bangladesh, however, is expected to rise to 80 percent of wheat area in 1977/78; on the other hand, the HYV rice area in Bangladesh has expanded more slowly than expected, and even the relatively low HYV proportions reported have been overestimated in recent years.[6]

In terms of country trends over the 12-year period, we would expect to find variable country progress along the usual S-shaped adoption curve (that is, the rate of adoption would start slowly, pick up speed, and then drop off as the innovation is widely used). The situation, as determined by charts (unpublished) drawn from the data presented in table 37, varies somewhat for wheat and rice.

—Wheat: In Nepal, India, and Pakistan the adoption process started very quickly. The rate of growth in India continued in almost a straight line through 1975/76, then declined in 1976/77.[7] The growth rate slackened in Pakistan in the early 1970's, but picked up in 1975/76 and 1976/77. The proportion in Nepal appears to have dropped off in 1975/76, and rose again in 1976/77. The growth rate in Bangladesh started slowly, but moved up sharply in 1975/76.[8]

—Rice: The rice situation is more complicated to summarize, in part because there are 11 rather than 4 countries, and the overall rates are lower. The rate of growth in India continues up in almost a straight line. The rate of growth in the Philippines has been slowing down—as might be expected after the high level of adoption—since about 1970. The level of adoption in Pakistan peaked in 1971/72, then dropped steadily through 1975/76 before rising slightly in 1976/77. (This is believed to be a result of government policies which favored the production of basmati rice for export.) The growth in Nepal and Bangladesh followed a more traditional pattern prior to leveling in the mid-1970's. Adoption in Korea (South)

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[6] See: *Workshop on Experience With HYV Rice Cultivation in Bangladesh*, Bangladesh Rice Research Institute, November 1976, 157 pp.; and Appendix C.

[7] The HYV area expanded significantly (9.2 percent) in 1976/77, but the total area expanded by even more (13.6 percent).

[8] The total wheat area also is expanding sharply in Bangladesh, so that subsequent proportions will not expand apace with the anticipated real growth in the HYV area.

Table 37—Estimated Proportion of Total Wheat and Rice Areas Planted to High-Yielding Varieties, Asia (South and East)[1]

Crop and country	Crop year											
	1965/66	1966/67	1967/68	1968/69	1969/70	1970/71	1971/72	1972/73	1973/74	1974/75	1975/76	1976/77
						Percent						
Wheat												
Bangladesh	—	—	—	7.2	8.6	10.6	11.9	17.9	23.7	26.3	71.8	72.9
India	negl.	4.2	19.6	30.0	30.1	35.9	41.1	51.4	56.1	60.4	74.7	71.8
Nepal	1.2	5.2	12.9	25.9	33.5	43.0	52.3	65.6	75.5	84.8	71.0	73.0
Pakistan	0.1	1.9	16.0	38.0	43.0	52.3	56.7	56.5	58.1	60.9	69.0	75.4
Rice												
Bangladesh	—	negl.	0.7	1.6	2.6	4.6	6.7	11.1	15.7	14.9	15.0	13.5
Burma	—	—	negl.	3.3	2.9	2.6	3.6	4.2	5.0	6.2	6.4	7.0
India	negl.	2.5	4.9	7.3	11.3	14.6	19.3	23.2	25.4	28.5	32.3	35.6
Indonesia	—	—	—	2.4	10.4	11.0	15.8	22.8	36.9	40.4	31.0	41.0
Korea (South)	—	—	—	—	—	—	0.2	15.6	11.8	25.5	22.5	43.9
Malaysia (West)	10.0	14.7	20.6	20.1	26.4	30.9	35.8	37.1	36.7	35.7	37.4	NA
Nepal	—	—	—	3.7	4.4	5.8	6.3	14.8	16.7	18.0	17.2	17.6
Pakistan	—	negl.	0.3	19.8	29.9	36.6	50.0	43.7	42.1	39.3	38.9	39.8
Philippines	—	2.7	21.2	30.4	43.5	50.3	56.3	54.0	63.4	64.0	64.4	68.1
Sri Lanka	—	—	—	1.0	3.9	4.6	10.6	33.2	54.8	51.7	63.0	NA
Thailand	—	—	—	—	negl.	0.4	1.3	4.2	5.0	5.5	7.1	11.3

[1] Excluding Communist nations.

and Sri Lanka increased rather sharply in the mid-1970's, with a drop in one year in each case. The growth rate in Malaysia leveled in the early 1970's. Adoption was rapid in Indonesia through 1974/75, appears to have dropped off in 1975/76 (though there is a possible problem of underreporting for the year), and rose again in 1976/77. The HYV proportion in Burma has grown slowly but regularly, while that in Thailand has increased gradually.

Future Rates of Adoption

Countries with current high levels of adoption are likely to face slower rates of expansion of HYV area in the future. Some nations are probably well along the adoption curve or approaching the top. For most major countries, moreover, the top of the curve for HYV's may be considerably below 100 percent.

Several supply and demand factors constrain adoption. On the supply side, (1) the present HYV's are not suitable for all soil and climate conditions, (2) they require seeds and inputs which are either not available or not fully utilized by every farmer (seed supply is still a problem in many areas), and (3) in some regions there is a strong demand for the longer straw of traditional varieties. On the demand side, (1) consumers may not prefer the HYV's over traditional varieties, and (2) government price policies may not encourage the production of HYV's. Although increased attention has been given to developing HYV's which meet local tasks and preferences, they still may not meet all consumer requirements. In some countries, as of 1978, wheat and/or rice supplies were becoming relatively adequate and less emphasis may be given, at least temporarily, to expanding HYV production.

Because of these and other factors, the HYV's are unlikely to completely replace traditional varieties in most major areas in the near future. Even if HYV adoption levels begin to taper off, however, this does not mean that yield levels will have to stagnate. New HYV's, with greater yield potential and/or stability, are constantly being developed. The use of other production inputs, such as fertilizer, is generally low and considerable potential for yield increases remains even after the initial HYV adoption curve levels off.

VI. APPENDIX

A. PUBLICATIONS ON ECONOMIC AND SOCIAL EFFECTS OF THE GREEN REVOLUTION

There has been a vast outpouring of reports on the economic and social aspects of the green revolution. The following publications represent some of the more useful general or multicountry studies:

Clifton R. Wharton Jr., "The Green Revolution: Cornucopia or Pandora's Box?," *Foreign Affairs*, April 1969, pp. 472–473; Dana G. Dalrymple, *Technological Change in Agriculture: Effects and Implications for Developing Nations*, U.S. Department of Agriculture, Foreign Agricultural Service, April 1969, 82 pp.; Joseph W. Willett, *The Impact of New Grain Varieties in Asia,* U.S. Department of Agriculture, Economic Research Service, ERS-Foreign 275, July 1969, 26 pp.; Lester R. Brown, *Seeds of Change,* Praeger, 1970, 205 pp.; Walter P. Falcon, "The Green Revolution: Generations of Problems," *American Journal of Agricultural Economics,* December 1970, pp. 698–710; F. F. Hill and Lowell S. Hardin, "Crop Production Successes and Emerging Problems in Developing Countries," in *Some Issues Emerging from Recent Breakthroughs in Food Production* (ed. by K. L. Turk), New York State College of Agriculture, Cornell University, 1971, pp. 3–29.

Also: Zubeida M. Ahmad, "The Social and Economic Implications of the Green Revolution in Asia," *International Labor Review*, January 1972, pp. 9–34; Randolph Barker, "The Economic Consequences of the Green Revolution in Asia," in *Rice, Science, and Man*, International Rice Research Institute, April 1972, pp. 115–126; Clive Bell, "The Acquisition of Agricultural Technology: Its Determinants and Effects," *The Journal of Development Studies,* October 1972, pp. 123–159; T. T. Poleman and D. K. Freebairn (eds.), *Food, Population and Employment: The Impact of the Green Revolution,* Praeger 1973, 272 pp.; Robert Evenson, "The Green Revolution in Recent Development Experience," *American Journal of Agricultural Economics,* May 1974, pp. 387–394; Keith Griffin, *The Political Economy of Agrarian Change; An Essay on the Green Revolution*, Harvard University Press, Cambridge, 1974, 264 pp.; *The Social and Economic Implications of Large-Scale Introduction of New Varieties of Foodgrains,* United Nations Research Institute for Social Development (Geneva), 1974, 55 pp.; Nicolas Wade, "Green Revolution," *Science,* December 20, 1974, pp. 1093–1096, December 27, 1974, pp. 1186–1192.

Also: *Changes in Rice Farming in Selected Areas of Asia,* IRRI, 1975, 377 pp.; Richard Perrin and Don Winkelman, "Impediments to Technical Progress on Small Versus Large Farms," *American Journal of Agricultural Economics,* December 1976, pp. 888–894; Ingrid Palmer, *The New Rice in Asia: Conclusions from Four Country Studies*, United Nations Research Institute for Social

Development (Geneva), 1976, 146 pp.; Grant M. Scobie and Rafael Posada T., *The Impact of High-Yielding Rice Varieties in Latin America, With Special Emphasis on Colombia,* Centro Internacional de Agricultura Tropical (CIAT), Cali, Series JE–01, April 1977, 165 pp.; Yujiro Hayami and Robert W. Herdt, "Market Price Efforts of Technological Change on Income Distribution in Semisubsistance Agriculture," *American Journal of Agricultural Economics,* May 1977, pp. 245–256; T.M. Arndt, D.G. Dalrymple, and V.W. Ruttan (eds.), *Resource Allocation and Productivity in National and International Agricultural Research*, University of Minnesota Press, 1977, 617 pp; William H. Bartsch, *Employment and Technology Choice in Asian Agriculture,* Praeger, 1977, 125 pp; B.H. Farmer (ed.), *Green Revolution? Technology and Change in Rice-Growing Areas of Tamil Nadu and Sri Lanka,* Westview Press, 1977, 429 pp. (also published by Macmillan in U.K.); Vernon W. Ruttan, "The Green Revolution: Seven Generalizations," *International Development Review,* 1977/4, pp. 16–13; Michael Lipton, "Inter-Farm, Inter-Regional and Farm-Non-Farm Income Distribution: The Impact of the New Cereal Varieties," *World Development,* March 1978, pp. 319–337; and V.W. Ruttan and H.P. Binswanger, "Induced Innovation and the Green Revolution," in *Induced Innovation; Technology, Institutions, and Development* (ed. by Ruttan and Binswanger), Johns Hopkins University Press, 1978, pp. 358–408.

B. THE DEVELOPMENT OF FLORENCE X AURORE WHEAT[1]

Florence x Aurore has long been one of the leading improved wheat varieties in North Africa. It played a role in the early Mexican breeding program (see Chapter II) and has served as a parent for numerous other improved varieties. Yet, its origins have been obscure. Since it represents one of the better improved varieties, it may be useful to briefly trace its origin and development.

Florence x Aurore was the result of a cross between two Australian varieties, Florence and Aurore, made in 1920 by Emile Schribeaux of the Station d'Essais de Semences of the Institut National Agronomique in Paris.

Florence, in turn, represented a Australian cross made by William J. Farrar in 1901 (and named in 1906) between two unnamed varieties descended from White Naples,[2] Improved Fife,[3] and Eden (Fulcaster). Florence was widely planted in Australia and also was grown in other countries.[4]

Aurore was also an Australian cross, made by Farrar, between Jacinth (from A. E. Blount, Colorado[5]) and Ladoga (a well-known spring red wheat of Russian origin[6]).[7] It was developed by Henry de Vilmorin in France.

Florence x Aurore was one of a packet of 19 F_2 generation varieties of seeds sent to Dr. F. Boeuf in Tunisia by Dr. Schribeaux on December 2, 1922[8] It was released for general cultivation in 1930/31 and is still widely grown. Florence x Aurore, under the name Marroqui, was used in the early Mexican breeding work.[9]

Lines subsequently selected from Florence x Aurore in Tunisia include Ariana 8 and Koudiat 17. Lines selected elsewhere include: 8193 in Algeria, 2511 in Morocco, and Blé d'Avril in France. A Florence x Aurore strain, selected in 1925, is known as Cailloux (registered in Tunisia as No. 588). Florence Aurore is also included in the parentage of a number of varieties, including Karaj 2 in Iran and Lakhish in Israel.

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[1] Based, except as noted, on letters and materials from: P. Auriau, Station Centrale de Génétique et d'Amélioration des Plantes, CNRA, Versailles, September 10, 1975, January 6, 1976; N. H. Luig, Plant Breeding Institute, University of Sydney, Castle Hill, New South Wales, October 1, 1975, January 5, 1976.

[2] "Richelle Blanche de Naples." Provided by Vilmorin. Described in *Les Meilleurs Blés*, Vilmorin-Andrieux, Paris, 1880, p. 44. Also see S. L. Macindoe and C. W. Brown, *Wheat Breeding and Varieties in Australia*, Department of Agriculture, New South Wales, Sydney, Science Bulletin No. 76, 1968 (3rd ed.), p. 216.

[3] A white-grained selection from Red Fife made by A. E. Blount of Colorado State University (Macindoe and Brown, *op. cit.*, p. 141).

[4] For background information on Farrar and Florence, see: J. Allen Clark, "Improvement in Wheat," *Yearbook of Agriculture*, 1936 (USDA), pp. 239–240; and H. Wenholz, *The Improvement of Australian Wheat; Milestones in its Progress*, Department of Agriculture, New South Wales, Sydney, 1937, pp. 1–3.

[5] Possibly a selection from Fife. According to Clark (*op. cit.*, p. 222): "A. E. Blount at the Colorado Agricultural Experiment Station was among the first to breed varieties by hybridization. Several of his wheats were sent to Farrar of New South Wales, and these entered into the parentage of some of Farrar's best wheats." No mention of Jacinth, however, has been found in USDA or Colorado State University files.

[6] See, for example, J. A. Clark and B. B. Bayles, *Classification of Wheat Varieties Grown in the United States in 1939*, U.S. Department of Agriculture, Technical Bulletin No. 795, June 1942, p. 116.

[7] Macindoe and Brown, *op. cit.*, pp. 57, 142.

[8] Dr. Auriau kindly provided a copy of Schribeaux's cover letter and a list of the other 18 varieties. Also see F. Boeuf, "Le Blé en Tunisie," *Annals du Service Botanique et Agronomique*, Tunis, Tome VIII, 1932, pp. 60–61.

[9] Norman E. Borlaug. "Wheat Breeding and Its Impact on World Food Supply," *Proceedings of the Third International Wheat Genetics Symposium*, Canberra, 1968, p. 5.

C. EXAMPLES OF OVERESTIMATION OF HYV RICE AREA

There are two known and documented cases of overestimation of HYV areas. Both involved rice in South Asia. One was rather localized, while the other was national in character.

The first occurred in India. In the southeastern half of North Arcot District of Tamil Nadu in 1972/73, official data for six tulaks indicated that 39 to 48 percent of the rice area was planted to HYV's. An unofficial survey of 545 farmers in the region, however, revealed that only 13.4 percent of the area was so planted. Thus, the official adoption data suggested a figure about three times as high as indicated in the survey. Whether the same results would have been found elsewhere in Tamil Nadu or other regions of India is, of course, not known.[1]

The second case, of more widespread nature, was in Bangladesh. The Ministry of Agriculture set up task forces to check the progress of the Aman (summer-fall) rice crop in late 1974 and late 1975 (the Aman crop represented 34.7 percent of the total HYV area in 1974/75, according to earlier official statistics cited in table 21). The reporting situation for Aus and Boro evidently was not examined:[2]

—The 1974/75 task force found that the stated HYV area was grossly overestimated for the country as a whole—perhaps by a factor of three. This overestimation was thought to have resulted from two factors: (1) "genuine overestimation" ("HYV rice is conspicuous and usually is in the foreground when seen from roads and paths"), and (2) "deliberate exaggeration" ("this probably occurred as a result of pressure from above to achieve high targets and show success").

—The 1975/76 task force found that "the degree of inflation is so variable, even within districts, that it is impossible to estimate what the actual HYV Aman acreage in the country might be. Almost certainly, the overall inflation is by at least 100 percent." The group felt that inflation of the HYV estimates has resulted from: (1) "lack of training and supervision of field staff," (2) "arbitrary alteration of UAA's reported acreages at all higher levels up to the Director," some of the field staff "knowing from past experiences that their reported figures will be altered, have lost interest in making realistic estimates"; and (3)

[1] B. Nanjamma Chinnappa, "Adoption of the New Technology in the North Arcot District," in B. H. Farmer, ed., *Green Revolution? Technology and Change in Rice-Growing Areas of Tamil Nadu and Sri Lanka*, Westview Press, Boulder, 1977, p. 96; letters from Mrs. Chinnappa, September 24, 1975, October 22, 1975, and Robert Chambers, September 11, 1975.

Results of a previous, but not quite comparable, survey of HYV rice production in three villages in the same district during the 1971/72 wet and dry seasons are provided in V. Rajagopalan, "North Arcot, Tamil Nadu," in *Changes in Rice Farming in Selected Areas of Asia*, IRRI, 1975, pp. 71–91. Background on the earlier program to introduce ADT–27 in North Arcot in 1967 and 1968 is provided by Stanley J. Heginbotham in *Cultures in Conflict: The Four Faces of Indian Bureacracy*, Columbia University Press, 1975, pp. 71–151,175–186 (the author also provides some brief comments on the situation in 1971 on p. 186).

[2] *HYV Task Force Reports, 1974–75 and 1975–76*, Bangladesh Agricultural Development Corporation, December 1976, 112 pp. (Enclosure to FAS report BD 7006 from Dacca, February 8, 1977.) The report was summarized in "Proper Statistics in Agri Sector a Must", *Bangladesh Times*, Dacca, January 11, 1977 (provided by Carl O. Winberg, Agricultural Attaché, American Embassy, Dacca, January 18, 1977).

"deliberate inflation of acreages at Thana and district levels, either to seek merit from, or avoid the wrath of, superior officers."[3]

The task force continued its check of the Aman rice crop during the 1976/77 season. The officially reported Aman area in 1976/77 was 24 percent less than in 1975/76.[4] This reduction represented in part an attempt to provide more realistic estimates than in the previous year, as well as a reclassification of Pajam (Mahsuri), a favorite variety, out of the HYV category.[5] The HYV area also was reduced because of a number of climatic, economic, and other conditions. Even though the 1976/77 HYV area figure was reduced, the task force concluded that the area continued to be overestimated. It was not possible to say precisely by how much because Pajam still was included in the HYV statistics for several unions. One calculation suggested the average degree of overestimation for the country was 53 percent, while at another point the group suggested that the actual HYV area was "appreciably below" the officially reported area of 1 million acres (0.42 million ha.). The former figure at least suggests a reduction in overestimation, compared with the previous 2 years.[6]

The big unknown is whether the HYV areas for the Aus and Boro crops also were overestimated, and if so, by how much. One observer, commenting on the 1975/76 situation in February 1976, suggested that the HYV Aus figures were "probably. . .inflated similarly," but that the Boro figures were more reliable, with an inflation of only 10 percent.[7]

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[3] In contrast, the HYV wheat area in 1975/76 also was examined but found to be *underreported* by 14.4 percent (whereas the traditional wheat area was *overreported* by 78.6 percent).

[4] The officially reported areas were 1,375,520 acres (556,700 ha.) in 1975/76 and 1,046,180 acres (423,400 ha.) in 1976/77 (*Monthly Statistical Bulletin of Bangladesh*, Bangladesh Bureau of Statistics, June 1977, pp. 20–21).

[5] Mahsuri is of intermediate height and represents a japonica x indica cross (Taichung 65 x Mayang Ebos 8012). As noted in Chapter II, it was originally crossed in India under a cooperative program with FAO, and further developed in Malaysia. It is widely grown in India (table 23, fn. 13) and Malaysia (table 26, fn. 5). It is considered a HYV in those countries and is so classified in this report. Thus its exclusion from the HYV category in Bangladesh means that the totals reported for that country are, in this respect, conservative.

[6] "HYV Aman Task Force, 1976," Ministry of Agriculture, Dacca, January 1977, pp. 1, 2 (provided by Joseph Stepanek, USAID).

[7] M.R. Talukder, "Slow Rate of Expansion of HYV Rice; Why and What Can be Done," *Workshop on Experience With HYV Rice Cultivation in Bangladesh*, Bangladesh Rice Research Institute, November 1976, p. 85.

D. GENETIC ASPECTS OF RICE BREEDING IN INDIA

A recent IRRI study traced the diffusion of rice genes into the programs of 18 plant breeders at 12 experiment stations in India. Crosses were examined for three periods: 1965–67, 1970–71, and 1974–75. Details of the findings are provided in an IRRI report;[1] only some highlights are noted here.

A substantial portion of the crosses studied involved at least one semi-dwarf parent: 80 percent in 1965–67 and 91 percent in 1970–71 and 1974–75. In the 1965–67 period, TN–1 was used in 41 percent of the crosses and IR–8 in 27 percent. By 1974–75, the direct involvement of these two varieties had dropped considerably (TN–1, 7 percent; IR–8, 17 percent), and the proportion involving at least one locally developed semi-dwarf had increased significantly (to 61 percent). But a large proportion of the locally developed varieties were progeny of TN–1 (39 percent) and IR–8 (55 percent). An additional 9 percent had both IR–8 and TN–1 in their ancestry. Of the remaining varieties, 3 percent had another IRRI parent and 6 percent had a non-IRRI parent.[2] "Thus, by the mid-1970's, the original short, stiff-strawed varieties were being phased out of the breeding programs as parents, but they continued to live on through a wide range of progeny" (p.7).

The types of parental materials changed over the decade studied. The proportion of parents which were indicas rose from 79 percent in 1965–67 to 96.6 percent in 1974–75. In the latter period, only 3 percent of the parental material was japonica. It is also of interest to note that:

> . . .the percentage of crosses that used varieties classified as unimproved increased from 1 to 7 percent over the ten-year period. That may indicate that breeders are going back to the original traditional sources of specific genetic traits as their programs become increasingly problem oriented (p. 8).

In terms of the varieties grown in the areas served by their experiment stations in 1975, 16 breeders estimated the breakdown as follows: semi-dwarf 50 percent, intermediate 17 percent (these would be classified as HYV's in this report), and tall 33 percent. Among the semi-dwarfs, the most popular varieties were Jaya (widely grown in 53 percent of the regions), IR–8 (27 percent), Ratna (13 percent), and IR–20 (13 percent). Among the most popular intermediate varieties were Pankaj (13 percent) and Mashuri (13 percent).

Of the 15 newest varieties, 83 percent were semi-dwarf and 17 percent intermediate. IR–8 or TN–1 were a parent or ancestor of each.

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[1] T. R. Hargrove, *Genetic and Sociologic Aspects of Rice Breeding in India*, IRRI, Research Paper Series No. 10, September 1977, 31 pp. A similar analysis of rice breeding programs in 10 Asian nations is noted briefly in *Research Highlights for 1976*, IRRI, 1977, p. 53; more detailed reports appear in the ***IRRI Annual Report for 1976***, 1977, pp. 137–143, and in T.R. Hargrove, *Rice Breeders in Asia*, IRRI, Research Paper Series No. 13, February 1978, 18 pp.

[2] "Percentages total more than 100 because several semi-dwarfs were progeny of crosses involving both IR–8 and TN–1, or IR–8 and Jaya" (p. 7).

In the case of 18 of the newest varieties, the following genetic strengths and weaknesses were noted:

Trait	Genetic strength	Genetic weakness
	Percent	
Yield potential	100	0
(fertilizer response)	(100)	(0)
(lodging resistance)	(100)	(0)
Grain quality	61	23
Growth duration	72	6
Disease resistance	61	73
Insect resistance	50	50
Cold tolerance	28	0
Drought resistance	11	6

The seemingly ambivalent situation caused by the relatively high proportions of "strength" and "weakness" for both disease and insect resistance is due to differing ratings for specific diseases and insects. Compared with the resistance ratings of the most widely grown varieties in 1975, they were considerably stronger (61 percent vs. 18 percent for diseases and 50 percent vs. 17 percent for insects); but the weakness ratings also were higher (73 percent vs. 58 percent for diseases and 50 percent vs. 30 percent for insects). The fact that the breeders tended to cite disease and insect susceptibility as a weakness more than resistance as a strength may indicate a strong concern for the incorporation of pest resistance into future varieties.

While insect and disease resistance clearly are important matters, and are so recognized by breeders, they were not given top ratings in the objectives for 46 crosses in 1974–75. The major stated objectives were:

Trait	Rating
	Percent
Yield potential	89
(fertilizer response)	(80)
(lodging resistance)	(80)
Grain quality	67
Growth duration	59
Disease resistance	43
Insect resistance	37
Cold tolerance	9
Drought resistance	9

A subsequent news account from India, however, reports that:

> Over the past three years Indian scientists have been sifting through the thousands of hybrid varieties. . .This time they are looking not for the highest yields with optimal doses of inputs, as they did until the early 1970's, but for seeds which will perform moderately well, even under rain-fed conditions, with little or no fertilizer.[3]

This may overstate the situation, particularly with respect to fertilizer, but may well reflect the current trend.

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[3] "India's Next Revolution," *The Economist*, May 28, 1977, p. 68.

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